BBC

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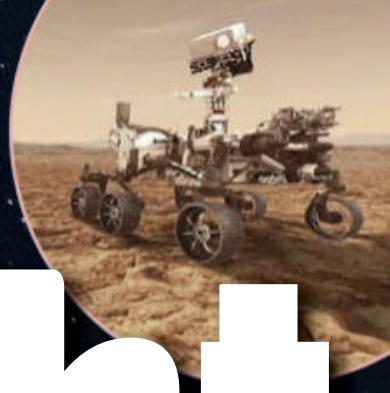
3 missions launch for the Red Planet this summer



#183 AUGUST 2020

Sky at Night

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SKYNEWS MAGAZINE REVIEW BY ALAN DYER

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ASTRONOMY NOW MAGAZINE REVIEW BY NIK SZYMANEK

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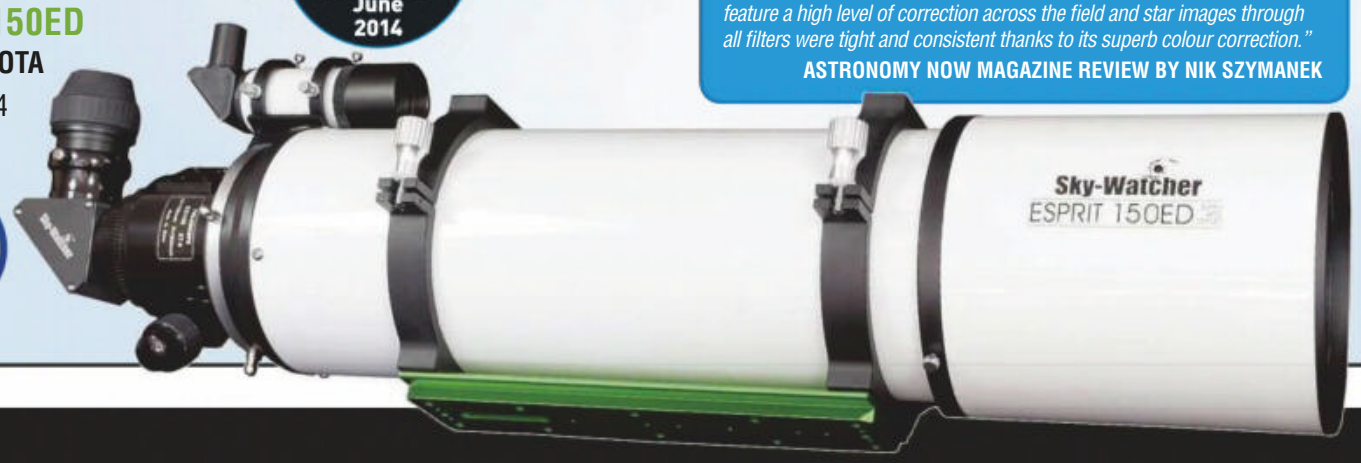

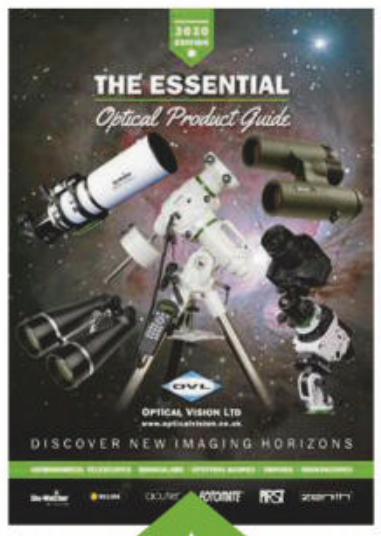

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Welcome

Don't let the Moon mar your meteor spotting

The Perseid meteor shower graces our skies mid-month and, as one of the most prolific, it's a highlight of the stargazing year. With increased rates of shooting stars possible around the shower's peak – theoretically upwards of one a minute, realistically perhaps one every five minutes – on what has every chance of being a balmy summer's evening, it's the ideal time to plan a night out under the stars, whether it's your first Perseids session or your fiftieth!

This year the Moon muscles in on the show: rising around midnight it's glow will have some impact on the number of meteors visible, but as Stuart Atkinson shows on **page 26**, that's no reason to let it spoil your observing. Instead, follow his tour around the best of the August night sky to take in some lovely summer sights in between shooting stars. You'll also find full details of timings for the Perseids, and charts of the radiant's position throughout the month in the 'Sky Guide' on **page 42**, while Pete Lawrence shares his astro imaging tips for photographing the perfect Perseid in our 'Capture' section on **page 68**.

It is astounding to think of what is happening on a large scale when a meteor shower to reach its peak: our planet on its orbit, ploughing through the trails of dust left by comets, on their own journeys around the Sun. Planetary scientist Penny Wozniakiewicz picks up this big-picture view in the 'Explainer' on **page 64**.

I hope you enjoy this and our look at the three upcoming Mars mission launches (**page 32**), our expedition to the mysterious farthest edge of the Solar System (**page 60**), and everything else in this issue.

Happy reading and clear skies!

Chris Bramley, Editor

PS Our next issue goes on sale on Thursday 13 August.

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New to astronomy?

To get started, check out our guides and glossary at **www.skyatnightmagazine.com/astronomy-for-beginners**

This month's contributors

Charlotte Daniels

Astrophotographer

"Processing is such an important part of astrophotography. I enjoyed going through each program and hope this guide helps any budding astro imagers." **Charlotte introduces image processing techniques,** page 55

Govert Schilling

Astronomy journalist

"Writing about these ambitious Mars missions made me realise once more how difficult planetary exploration really is. I can't wait to see the results". **Govert catches up with three Mars expeditions,** page 32

Penny Wozniakiewicz

Planetary scientist

"During meteor showers I'm always blown away by the thought that Earth is travelling through a dusty debris trail left by a comet." **Penny explains what causes meteor showers like the Perseids,** page 64

Extra content ONLINE

Visit **www.skyatnightmagazine.com/bonus-content/Y4Y6SQV/** to access this month's selection of exclusive Bonus Content

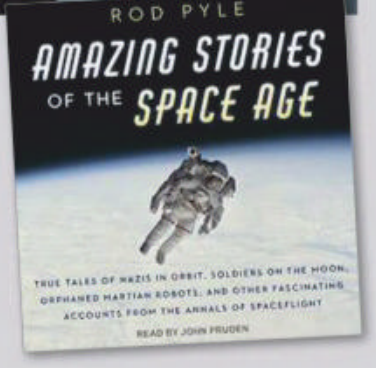
AUGUST HIGHLIGHTS

Interview: The End of Everything

From 'heat death' to the 'big rip', astrophysicist Katie Mack reveals how the Universe might end.

Watch June's episode of *The Sky at Night*

Maggie talks to NASA astronaut Jessica Meir about life on the ISS and taking part in the first all-female spacewalk.



Audiobook preview: Amazing Stories

Download and listen to two chapters from US space writer Rod Pyle's book *Amazing Stories of the Space Age*.

The Virtual Planetarium

Pete Lawrence and Paul Abel guide us through the best sights to see in the night sky this month.

DAZZLING DEATH THROES

Hubble reveals the spectacular demise of the ‘Jewel Bug’ Nebula

HUBBLE SPACE TELESCOPE, 18 JUNE 2020

The ‘Jewel Bug’, the ‘Gummy Bear’ and the ‘Magic Carpet’... planetary nebula NGC 7027’s various monikers over the years all hint at its intriguingly idiosyncratic shape, revealed more spectacularly than ever before in this new image.

Taken for the first time with the full range of Hubble’s Wide Field Camera 3 instrument, spanning from near-ultraviolet to near-infrared light, it shows an incredibly complex and rapidly evolving picture. Fast stellar winds slam into slowly expanding dense clouds of dust, creating bubble-like cavities and jets. Scientists suspect the eccentric patterns point not to one but two dying stars at its centre. They may have been placidly interacting and throwing out material for thousands of years but are now violently collapsing, or it could be that a red giant star abruptly swallowed its smaller stellar companion. Whatever the explanation, it has reached a rapid, violent – and beautiful – end game.

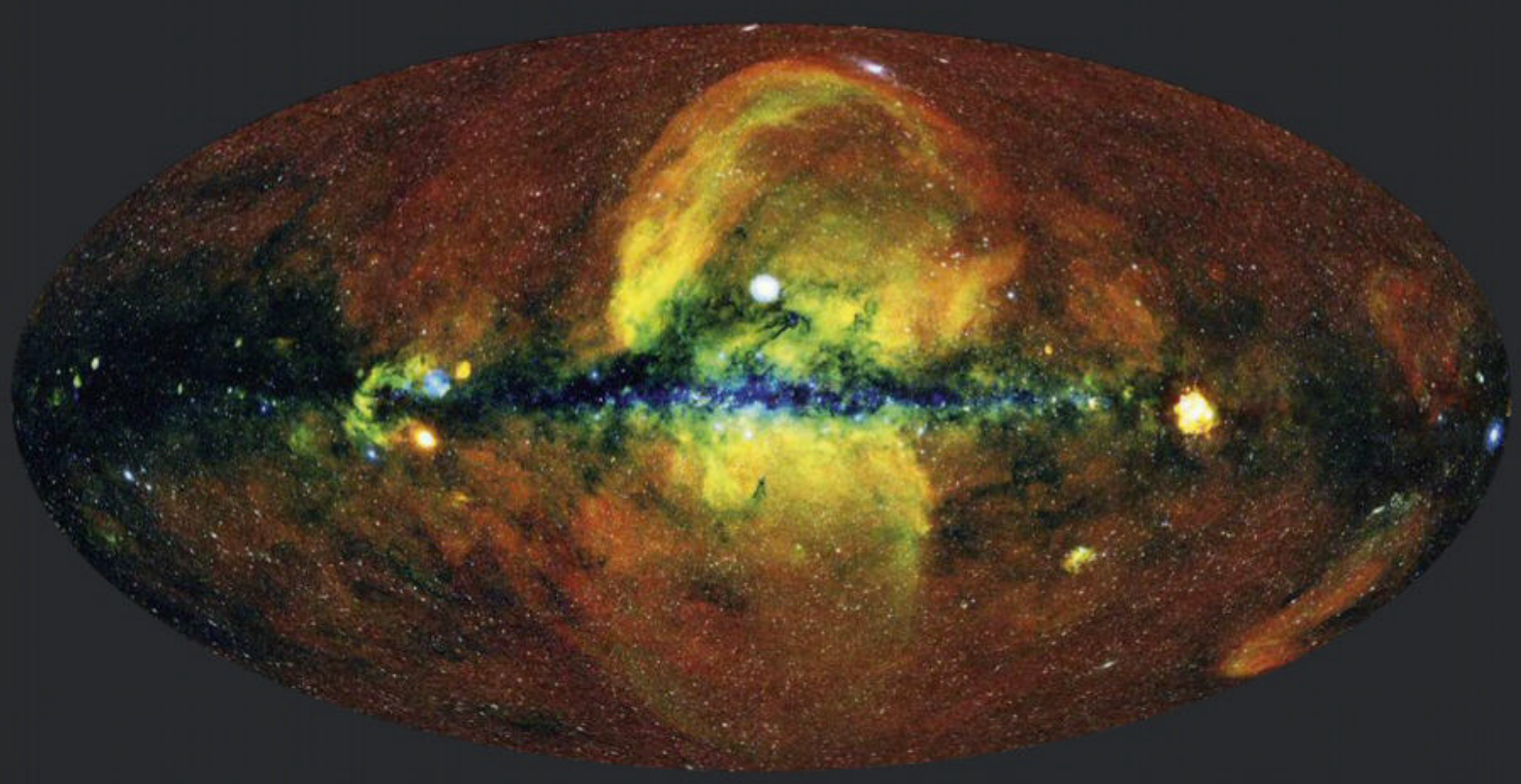
MORE **ONLINE**
A gallery of these and more stunning space images

NASA/ESA AND J. KASTNER (RIT)

△ On a knife edge

HUBBLE SPACE TELESCOPE, 22 JUNE 2020

Galaxy NGC 5907, the Knife Edge Galaxy, is a spiral just like our Milky Way, but it appears as a long line of dust and stars from Hubble's edge-on perspective. Discovered in 1788 by William Herschel, it's around 50 million lightyears away in Draco. The Knife Edge is encircled by an arch of stars not visible in this image, a remnant of a small dwarf galaxy torn apart by NGC 5907 over 4 billion years ago. This image was processed by citizen scientist Judy Schmidt (Geckzilla).



▽ Cosmic fingerprint

SOFIA, HERSCHEL SPACE OBSERVATORY, HUBBLE SPACE TELESCOPE, 2 JUNE 2020

This SOFIA image reveals magnetic fields in our Milky Way's core. Combined with data from Hubble and Herschel, researchers found fields that may control matter moving around Sagittarius A's supermassive black hole.

△ All-sky X-ray vision

EROSITA TELESCOPE, 19 JUNE 2020

eROSITA has been busy out in orbit at L2, 1.5 million lonely kilometres from Earth. Launched aboard the Russian-German Spektr-RG observatory from Baikonur in July 2019, it has just completed its first full X-ray survey of the sky. Peering four times deeper than the previous all-sky X-ray survey by the ROSAT telescope 30 years ago, the detail revealed is unprecedented, with over a million high-energy objects found. The instrument will pan across the sky every six months for four years to create seven more X-ray surveys of the hot Universe.

△ Butterfly effect

HUBBLE SPACE TELESCOPE, 18 JUNE 2020

As delicate as the Butterfly Nebula, NGC 6302, may look, its wings are churning and burning at 250,000°C as – like NGC 7027 on the previous page – it splits itself apart on an extremely short timescale. NGC 6302, 3,800 lightyears away in Scorpius, was formerly a huge red giant, 1,000 times the diameter of the Sun. Now in its dying phase, it is spewing out gas and dust as it rapidly casts off its outer layers.

Born yesterday ▷

VERY LARGE TELESCOPE, 20 MAY 2020

The bright yellow 'twist', circled deep within this spiralling protoplanetary disc surrounding young star AB Aurigae may be the first direct evidence of a planet being born. The SPHERE (Spectro-Polarimetric High-contrast Exoplanet Research) instrument on ESO's Very Large Telescope revealed the structure 531 lightyears away in the constellation of Auriga. The twist is thought to mark the connection of two spirals either side of the planet's orbit, one winding inwards and one expanding outwards, with gas and dust accreting onto the forming planet.

ESA/HUBBLE & NASA/R. DE JONG/ACKNOWLEDGEMENT: JUDY SCHMIDT (GECKZILLA), JEREMY SANDERS/HERMANN BRUNNER AND THE ESASS TEAM (MPE) EUGENE CHURAZOV/MARAT GILFANOV (ON BEHALF OF IKI), NASA/SOFIA/L. PROUDFIT/ESA/HERSCHEL/ HUBBLE SPACE TELESCOPE, NASA/ESA AND J. KASTNER (RIT), ESO/BOCCALETTI ET AL

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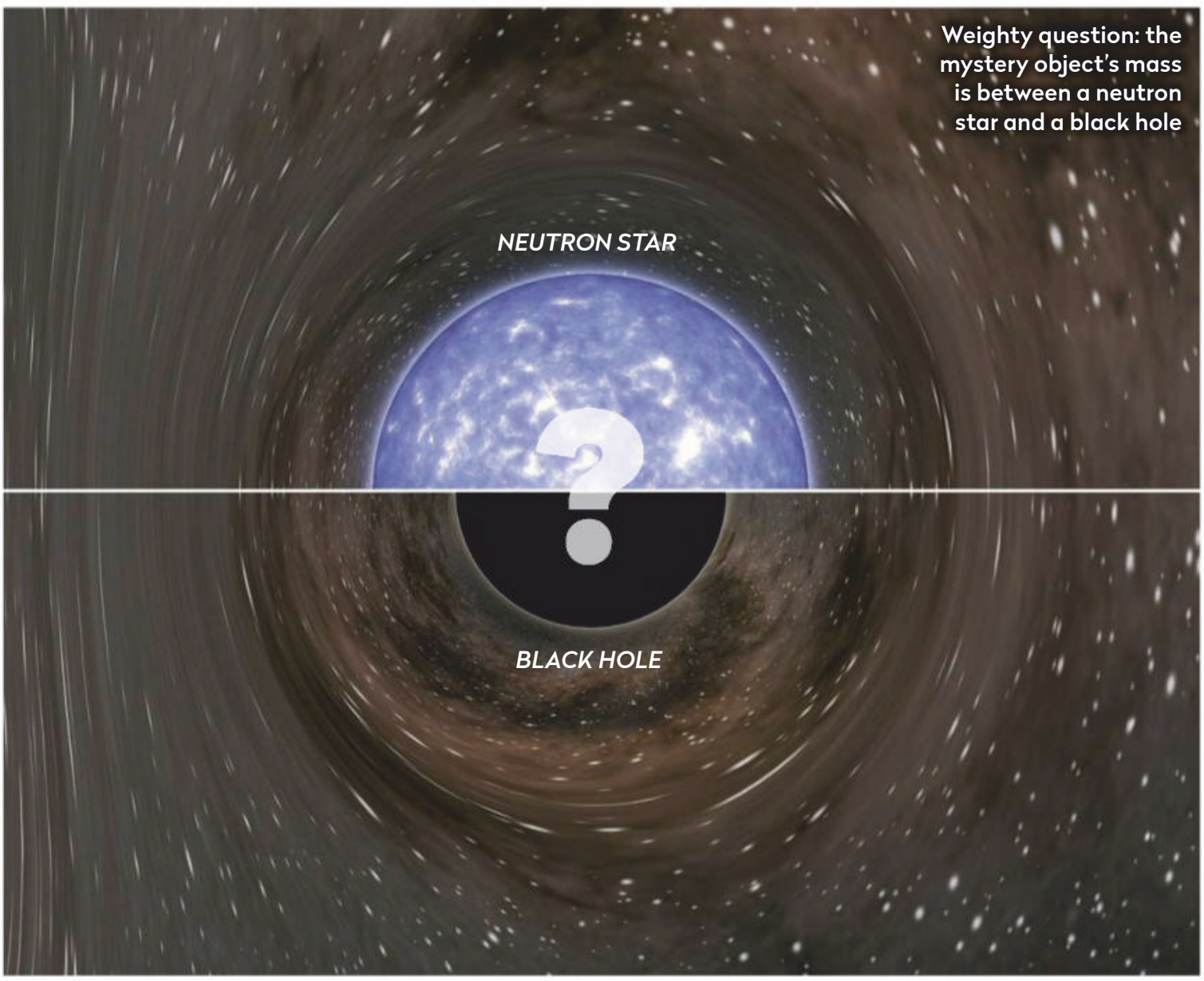


Weighty question: the mystery object's mass is between a neutron star and a black hole

ILLUSTRATION NASA'S SCIENTIFIC VISUALIZATION STUDIO/CONCEPTUAL IMAGING LAB, HONGLOUWAWA/ISTOCK/GETTY IMGFES, ASTRONOMERS WITHOUT BORDERS X 2

Mystery object bridges black hole gap

Is it the heaviest neutron star or the lightest black hole?

A ripple in space time has allowed astronomers to discover a rare object that bridges the gap between black holes and neutron stars, a recent report has announced. The find could give astronomers insight into how these dense objects form.

Black holes and neutron stars are both incredibly dense objects created during the deaths of the Universe's largest stars. Which one forms depends on the mass of the dying star, with black holes arising from the largest. Over the years, astronomers have found no neutron stars heavier than 2.5 solar masses, while the lightest black hole discovered is 5 solar masses, leaving a 'mass-gap' where no objects seem to exist, until recently.

Last summer, astronomers at the LIGO and Virgo interferometer observatories were searching for gravitational waves, ripples in space time created by the merging of large objects. On 14 August 2019, they detected a wave from a 23 solar-mass black hole merging with an object of 2.6 solar masses.

"The reason these findings are so exciting is because we've never detected an object with a mass firmly inside the theoretical mass gap between neutron stars and black holes before," says Laura Nuttall from the University of Portsmouth, part of the LIGO-Virgo team. "Is it the lightest black hole or the heaviest neutron star we've ever seen?"

The merger is also exciting for the big difference in the masses of the pair, larger than any other merging system that has been observed to date. The discrepancy is making astronomers reassess their theories about how black holes pair up before merging together.

www.ligo.caltech.edu

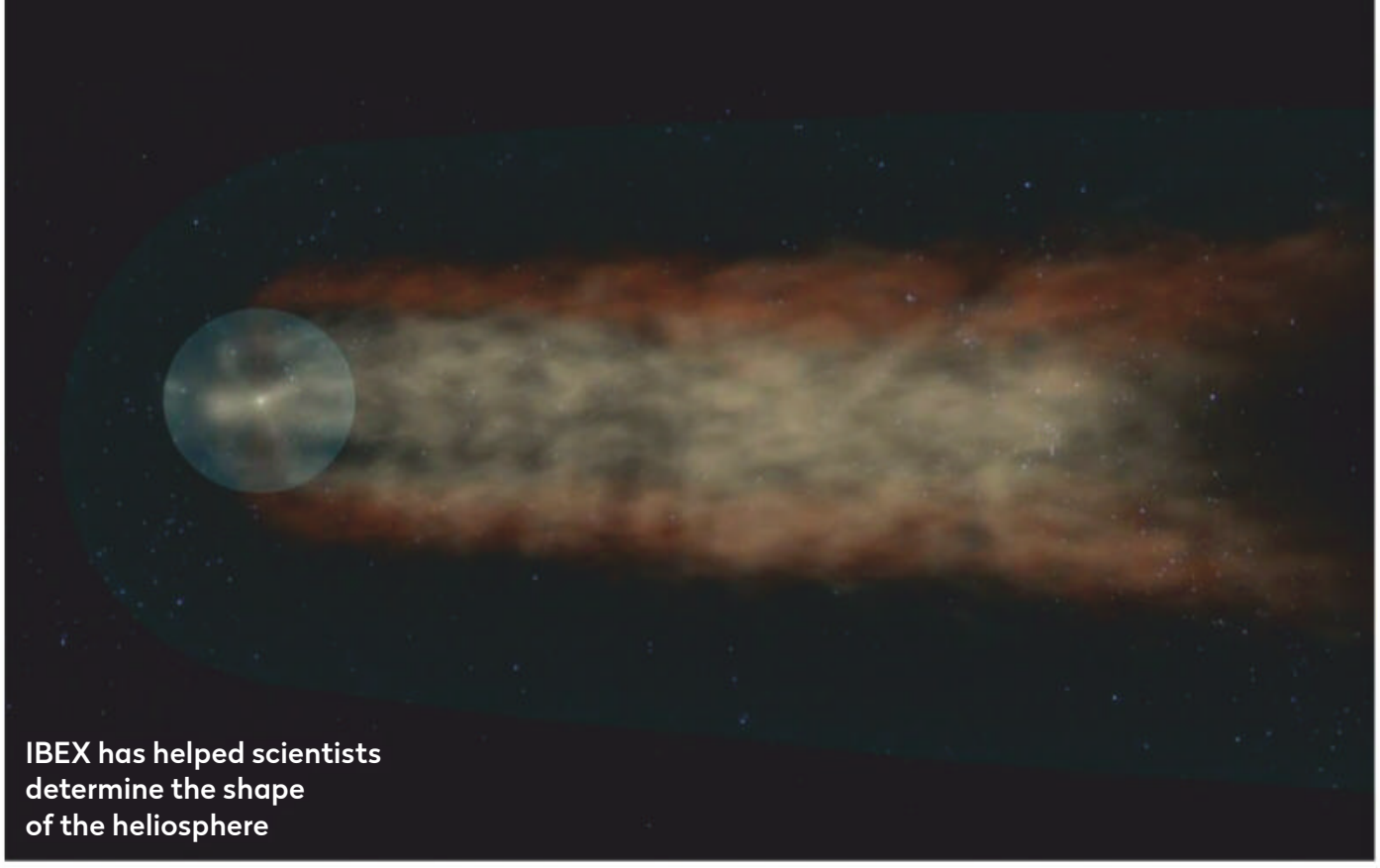
Comment

by Chris Lintott

The idea of a gap between the heaviest neutron stars and the lightest black holes comes from our ideas about how these objects form. Both are believed to be the result of the deaths of massive stars, but the star's destiny depends on its initial mass.

The largest stars explode in supernovae when nuclear fusion at their cores is halted once fuel is used up. There is an initial collapse, which for stars that begin life with a mass greater than 30 Suns, cannot be halted, resulting in a massive black hole. For less massive stars, a rebound carries away most of the mass, leaving a neutron star of 1.4 solar masses. To find an object which fits neither scenario tells us something is missing from this simple picture.

Chris Lintott co-presents *The Sky at Night*



ILLUSTRATION

IBEX has helped scientists determine the shape of the heliosphere

Solar System's edge charted over solar cycle

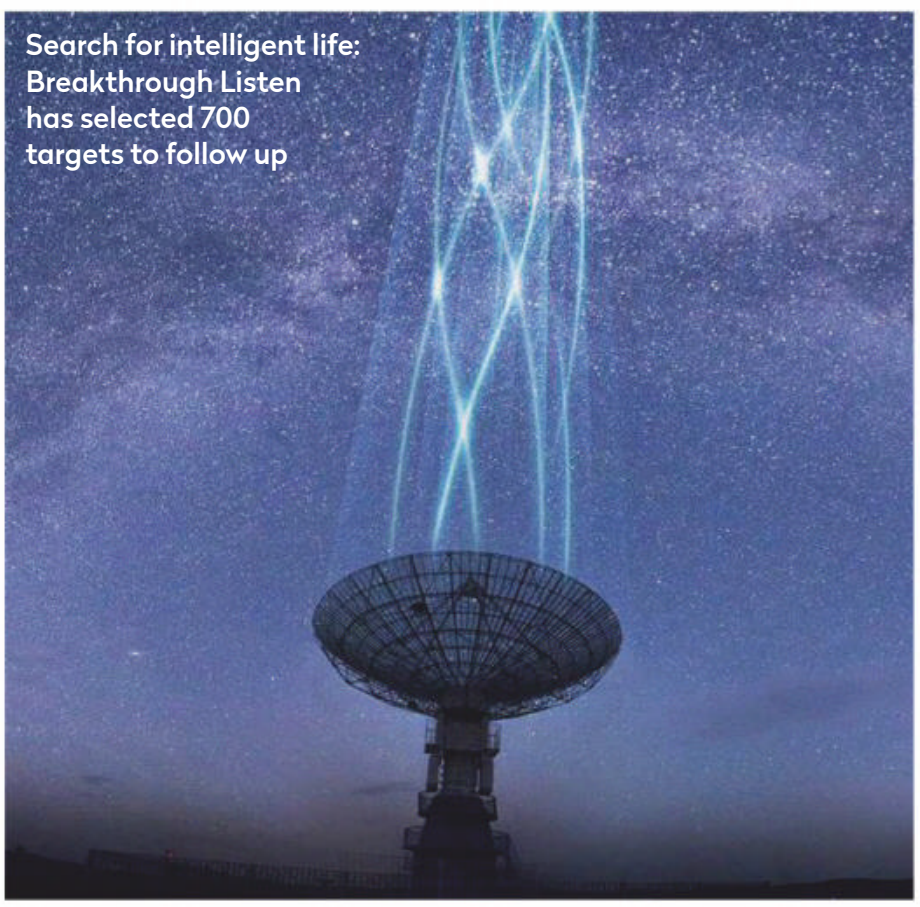
Astronomers have watched the region respond to the Sun's activity

A project to map the outer edge of the Solar System has just completed an entire solar cycle's worth of observations. For the last 11 years, NASA's Interstellar Boundary Explorer (IBEX) has mapped the bubble of particles created by the solar wind, known as the heliosphere. With a complete cycle now observed, astronomers are able to look at how the heliosphere responds to the Sun's changing activity, such as how it inflates like a balloon when the solar wind gusts.

"It takes [two to three] years for these effects to reach the edge of the heliosphere," says Jamey Szalay, an IBEX researcher from Princeton University. "For us to have this much data from IBEX finally allows us to make these long-term correlations."
http://ibex.swri.edu/

▸ Turn to page 60 to discover more about observing the heliosphere and beyond

Most diverse list of potential alien habitats



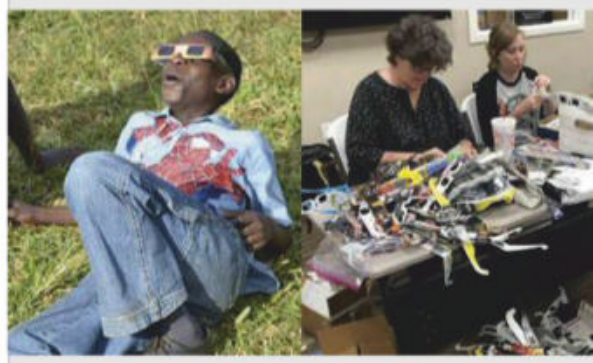
Search for intelligent life: Breakthrough Listen has selected 700 targets to follow up

An initiative hunting the skies for signs of intelligent life, Breakthrough Listen, has released a list of 700 targets of potential interest in June.

The 'Exotica' catalogue contains one of almost every kind of astronomical target in the observable Universe – from ordinary comets to the most exotic galaxies. Its aim is to increase the diversity of targets being explored for technosignatures – indicators such as radio waves or laser pulses being given off by an advanced civilisation. This will help astronomers broaden their search for intelligence away from only environments that resemble Earth, to include a full range of possible habitats.

"When it comes to the search for intelligent life, it's vital to have an open mind," says S Pete Worden, executive director of the Breakthrough Initiatives. "Until we understand more about the forms another civilization and its technology could take, we should investigate all plausible targets. Cataloguing them is the first step towards that goal."
breakthroughinitiatives.org

NEWS IN BRIEF



Eclipse glasses to Ethiopia

Outreach group Astronomers Without Borders distributed over 16,000 recycled eclipse glasses around the town of Lalibela, Ethiopia, on 21 June so that locals could safely watch the annular solar eclipse that was passing overhead. The glasses were collected after the US eclipse which occurred in 2017.

JWST delayed

NASA has confirmed its latest flagship mission, the James Webb Space Telescope, will miss its March 2021 launch date due to the COVID-19 pandemic. The mission was meant to launch in 2018, but has been beset by delays. However, NASA's associate administrator for science, Thomas Zurbuchen, says: "I'm very optimistic about this thing getting off the launch pad in 2021."

Milky Way has six billion Earths

As many as six billion Earth-like planets could exist within our Galaxy, according to a new study. The report found that roughly one in five Sun-like, or G-type, stars could host a rocky, roughly Earth-sized planet. Around 7 per cent of the Milky Way's 400 billion stars are G-type bodies.

Familiar ground: could there be life on exoplanet KOI-456.04?

ILLUSTRATION

ENRICOAGOSTONI/ISTOCK/GETTY IMAGES, VLA, NASA/JHUAPL/SWRI, SOLARSEVEN/ISTOCK/GETTY IMAGES

Earth-sized planet found hiding around Sun-like star

The pair are the closest match to the Sun and Earth yet detected

A distant star and its planet, which bear a close resemblance to our own Sun and Earth, have recently been discovered.

The planetary system was found in data from the exoplanet-hunting Kepler Space Telescope, which looked for dips in brightness caused by planets transiting across their stars' discs. This photometric transit method favours the detection of Earth-sized planets around dim, red dwarf stars rather than around those like our Sun. Red dwarfs are relatively cool, however, and emit high-energy solar flares, characteristics which could render such planets more hostile to life.

But Kepler-160, the host star of this newly discovered planet, is only slightly larger than our Sun and has a temperature of 5,200°C – only 300°C cooler. Astronomers already knew the star had two Neptune-sized planets from an initial analysis of the Kepler data, but there were fluctuations in their timing that suggested another planet might be present in the star's planetary system.

A team from the Max Planck Institute for Solar System Research (MPS) went back over the data using a new technique to tease out the subtle signs of two smaller planets moving around the star.

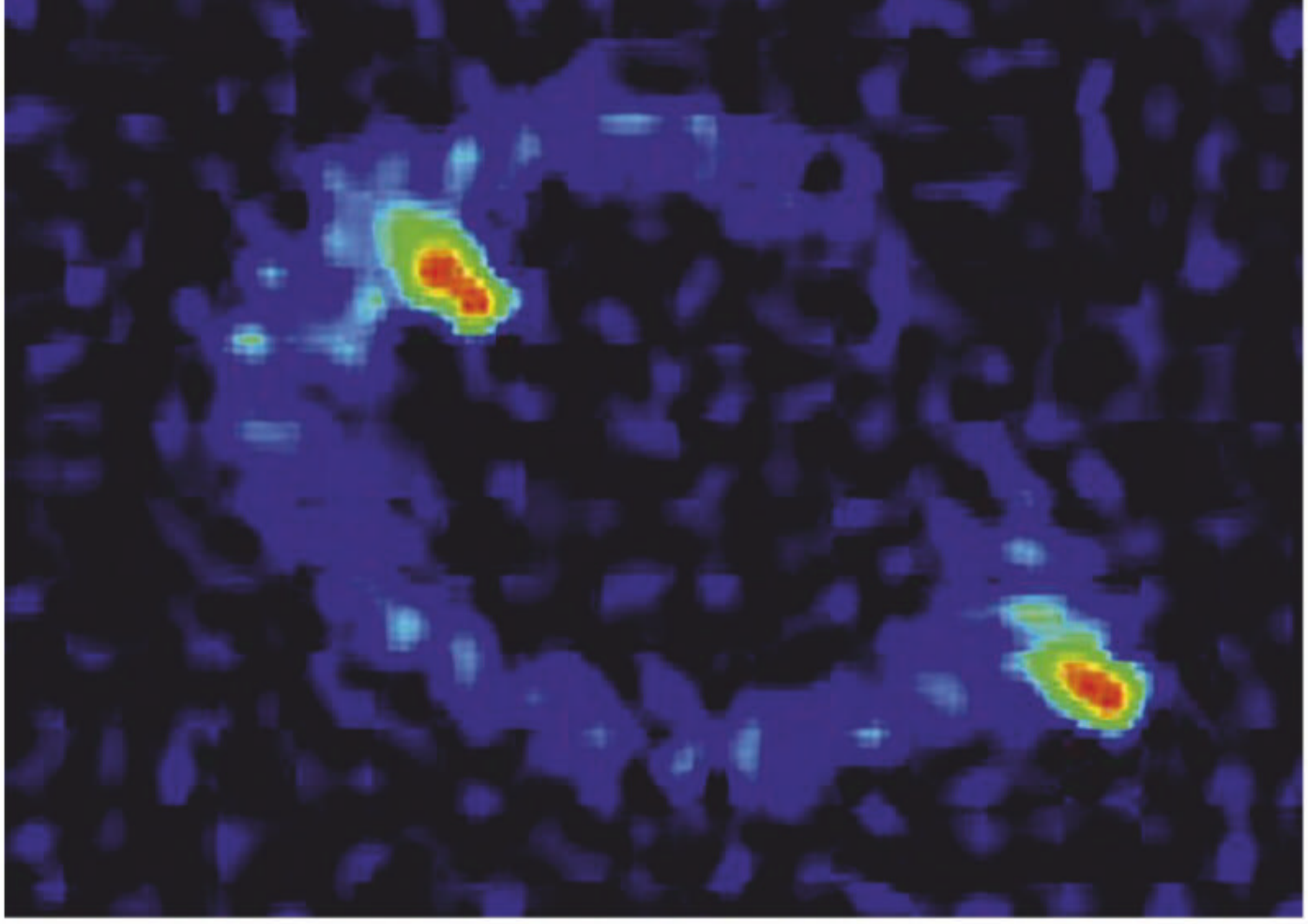
"Our analysis suggests that Kepler-160 is orbited by a total of four planets and not by two," says René Heller from MPS, who led the team.

One of the two new stars could only be detected indirectly, but the other, KOI-456.04, is 1.9 times the radius of Earth and orbits its star once every 378 days – just 13 days longer than an Earth year.

"Our improvement is important in the search for small, Earth-sized planets," says Heller. "The planetary signal is so faint that it's almost hidden in the noise of the data."

It's Sun-like host star means the light falling on the planet will be very similar to our own sunshine, rather than the infrared-laden light of a red dwarf.

"KOI-456.04 is relatively large compared to many other planets that are considered potentially habitable. However, it's the combination of its size, at less than double that of Earth, and its solar-type host star that makes it so special and familiar," says Heller.



▲ A radio image of the first known Einstein ring, observed in 1987 by the Very Large Array telescope

Distance to first Einstein ring measured

Locked-down science allows time to revisit a decades-old question

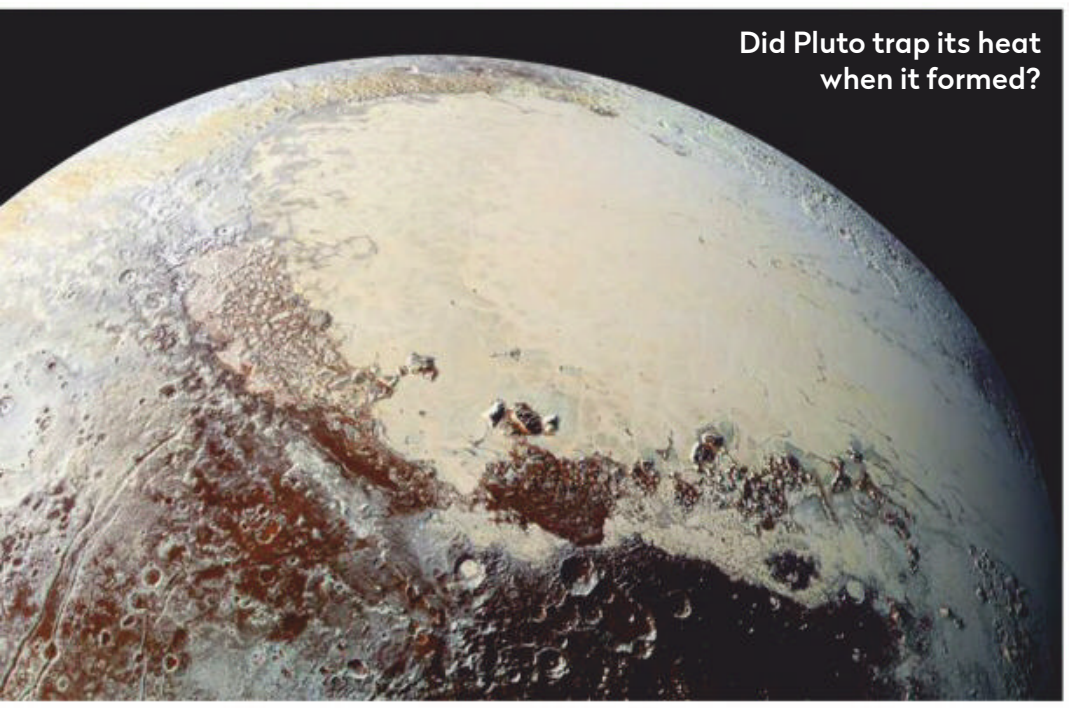
Though most of the world's professional telescopes shut down for several months due to the COVID-19 pandemic, astronomers did not sit idly at home. Two scientists, Daniel Stern and Dominic Walton, spent the time going through 20-year-old data, unpicking the mysteries of the first Einstein ring ever discovered.

An Einstein ring forms when light from a distant object is bent by gravity, which distorts its image into a ring shape. Astronomers found the first one in 1987, though it has been observed by many NASA telescopes since and the data is now publicly available.

"As we dug deeper, we were surprised that such a famous and bright source never had a distance measured for it," says Stern, from NASA's Jet Propulsion Laboratory. Using the archived data, the pair measured that the distant object is 10 billion lightyears away.

https://www.jpl.nasa.gov/

Warm beginnings for Pluto



Did Pluto trap its heat when it formed?

Pluto might have had a hot start, a new study suggests. Planetary scientists know the dwarf planet currently has a subsurface water ocean, but they are uncertain about how long it has been there. The traditional formation theory has Pluto beginning as a frozen ball which was later thawed by radioactive rocks, but another theory proposes that the dwarf planet retained enough heat from its genesis to maintain a liquid ocean throughout its life.

These two processes both involve complex, but different, patterns of thawing and refreezing. Each creates a specific type of surface feature, which geologists can use to differentiate between the two theories. "Now that we have images of Pluto's surface from NASA's New Horizons mission, we can compare what we see with the predictions of different thermal evolution models," says Francis Nimmo from the University of California, who took part in the study.

The features in these images seem to suggest that Pluto began warm, meaning it must have trapped almost all of the heat from its initial formation.

http://pluto.jhuapl.edu/

NEWS IN BRIEF

ILLUSTRATION

Black hole background

Every year, signals from two million black hole mergers pass by Earth undetected, but that could change. Physicists from the LIGO-Virgo observatory have developed a technique which, rather than looking for gravitational waves created by individual strong mergers, instead picks up the background noise from weaker mergers.

Moon by 2024 in question?

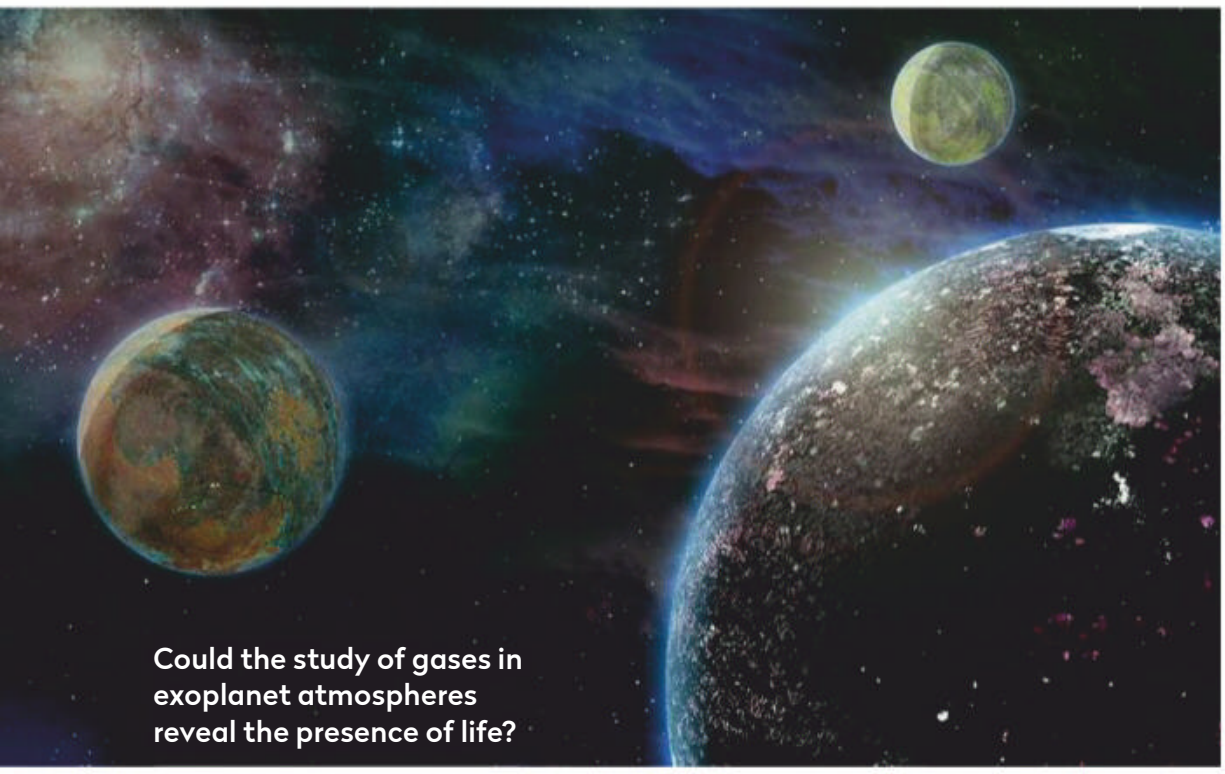
NASA's new head of human spaceflight, Kathy Lueders, says she could not guarantee the agency will achieve its goal of landing a human on the Moon by the end of 2024. "We're going to try," says Lueders. "It's important to have an aggressive goal. It gets the team focused on the importance of the mission."

Nearest brown dwarf found

Citizen scientists from the Disk Detective project have discovered the closest brown dwarf to Earth – 332 million lightyears away. "That proximity is important, because brown dwarfs are lower in mass and less bright than other objects like stars," says Maria Schutte from the University of Oklahoma, who followed up the discovery.

Our experts examine the hottest new research

CUTTING EDGE



Could the study of gases in exoplanet atmospheres reveal the presence of life?

Seeking signs of alien life

Next generation telescopes could help astronomers find distant biosignatures

Every now and then in 'Cutting Edge' we return to advances in the search for life beyond Earth. Current efforts are focused both on finding single-celled extra-terrestrials within our own Solar System, as well as on exoplanets orbiting other stars in the Galaxy. Both strategies have their own strengths and weaknesses. We are able to physically explore the Solar System close-up with robotic probes, but even places like Mars or the moon Europa seem inhospitable compared to Earth. On the other hand, there are an enormous number of habitable planets across the Galaxy, but we can only observe them remotely. The signs of life, or biosignatures, on an exoplanet would have to be globally conspicuous to be detectable.

McCullen Sandora and Joseph Silk, both associated with the Institut d'Astrophysique de Paris, have been taking stock of our current knowledge of promising exoplanet biosignatures which upcoming telescopes could let us search for.

Many of the biochemical processes of life release gaseous by-products that can build up to detectable levels in the planet's atmosphere. These could help reveal how advanced life has evolved, as over the history of life on Earth biology has progressed through a sequence of evolutionary transitions, including the development of photosynthesis (growing by the energy of sunlight and releasing oxygen), multicellular life like trees and animals, and technological civilisation – all of which give off different biosignatures.

The methane gas in Earth's atmosphere was overwhelmingly released by life. Methane-producing biochemistry appears to have evolved early on Earth, and so detecting this gas could be a good indicator that an exoplanet is hosting microbial life. Other biosignature gases include methyl chloride or dimethyl sulfide – the characteristic smell of the sea that's released in large amounts by plankton and coral.

Signs of a biosphere

Once a biosphere has evolved photosynthesis it will lead to a slow accumulation of oxygen in the atmosphere. This began on Earth around 2.5 billion years ago, but the levels of atmospheric oxygen wouldn't be directly detectable until they have built up to near present-day levels of 20 per cent. It's actually much easier to detect its by-product, ozone, which has the added benefit of shielding the planet's surface from high levels of ultraviolet radiation.

As for intelligent alien life – if SETI (Search for Extraterrestrial Intelligence) efforts are successful, and we detect an unambiguously artificial radio signal from an extrasolar planet – that would be an open-and-shut case. However, we could detect more general signatures of technological civilisations that have an effect on their homeworld's atmosphere. Industrial air pollution like CFCs have no known geological source and stick around for tens of thousands of years. We could detect the spectral signature of solar panels, if the planet is covered with enough, or even see the artificial lights from cities.

"Many of the biochemical processes of life release gaseous by-products that can build up to detectable levels in a planet's atmosphere"

Prof Lewis Dartnell is an astrobiologist at the University of Westminster

Crucially, say Sandora and Silk, we will soon be advancing from merely speculating about tell-tale signs, to having the capability to detect such signatures with sophisticated telescopes. For example, Sandora and Silk anticipate that the Extremely Large Telescope (ELT) under construction on the top of Cerro Armazones in Chile will be able to target 10 to 20 rocky habitable-zone planets for atmospheric signs of microbial life or photosynthesis. And if the proposed 15m LUVOIR space observatory is funded and built, it could survey over 100 Earth-like planets for technological signatures.

Lewis Dartnell was reading... *Biosignature Surveys to Exoplanet Yields and Beyond* by McCullen Sandora and Joseph Silk. **Read it online at https://arxiv.org/abs/2005.04005**

PHOTOSTOCK-ISRAEL/ISTOCK/GETTY IMAGES, VIKTAR/ISTOCK/GETTY IMAGES

Tracking wide binaries in star clusters

The crowded regions tend to pull stellar pairs apart

Prof Chris Lintott is an astrophysicist and co-presenter of *The Sky at Night*

From my first sight of Albireo through a telescope, with its blue and yellow components, I've always been fascinated by binary stars. They've always seemed to me too fragile an arrangement to survive.

That instinct isn't wrong; all but the closest and most tightly bound binaries are vulnerable to being pulled apart by gravitational interactions with passing stars or their surroundings. In this month's paper, Niall Deacon (Max Planck Institute for Astronomy and Adam Kraus (University of Texas at Austin) look at double stars within some well-known open clusters, to see how they are holding up.

We know that binaries are common – nearly half of solar-type stars are in pairs, with half of those being separated by more than 100 Astronomical Units (where 1 AU is the Earth to Sun distance), and hence vulnerable to disruption. If these systems are indeed easily disrupted by interactions, we should expect more of them when we look at younger populations, such as those in open clusters.

The clusters studied in this month's paper include some of the most famous and familiar in the sky, but the authors use the latest data and techniques. The team looked through the data from ESA's Gaia satellite in order to identify members of the Pleiades, Beehive and Alpha Persei clusters. Gaia's ability to provide information on how stars are moving is critical here; stars that move together can be identified as cluster members, rather than interlopers that just happen to lie in the same part of the sky.

Making a move

This technique identifies large numbers of cluster stars; over a thousand for the Pleiades and Beehive, and 815 for Alpha Persei, and the information on how stars move can be even more useful. Stars in binaries – even wide binaries – should be moving together through space, and the precision of the Gaia measurements is such that such associations stand out from the collective motion of the cluster. Think about finding groups of friends in a crowd; the crowd may all be moving in the same direction, but you can spot groups by the fact they move together.

"Stars that move together can be identified as cluster members, rather than interlopers that lie in the same part of the sky"

In each case, between 2–3 per cent of stars turn out to be in wide binaries, a number that is noticeably lower than for stars which do not lie in such clusters. This makes sense; stars formed within the dense environment of a cluster like these are much more likely to suffer a close interaction with a neighbour. Stars jostle within the cluster itself and such encounters seem to have the effect of disrupting binaries.

It's especially telling that the fraction of binaries is lower in the known clusters than in objects called young moving groups. These loose agglomerations of stars travel together across the sky and probably represent the result of star formation in lower density environments – where encounters will be less common and thus where binaries can live relatively unmolested lives. The authors also make a comparison to a group of young stars known as the Pisces-Enceladus stream, which is the same age as the Pleiades. The difference in their number of binaries seems to confirm that – at least for wide binaries – it's not how old you are that matters, it's where you were born.

By using Gaia satellite data, scientists have a detailed view of how binary stars behave in open clusters like the Pleiades

Chris Lintott was reading... *Wide binaries are rare in open clusters* by NR Deacon and AL Kraus. **Read it online at: https://arxiv.org/abs/2006.06679**

The Sky at Night TV show, past, present and future

INSIDE THE SKY AT NIGHT

▲ **Dimming down? With the help of citizen scientists, astronomers have been researching why the most familiar sight in Orion, Betelguese (top left), has been getting dimmer**

In July's episode of *The Sky at Night*, astronomer **Emily Cannon** talks to the team about her work on Betelguese, a red supergiant star that's had something of a fainting spell recently

Betelgeuse, Betelgeuse, Betelgeuse... Arguably the most famous of the red supergiants, Betelgeuse continues to give us a unique insight into the workings of the largest stars in the Universe. If one were placed at the centre of our Solar System, it would extend past the orbit of Jupiter, expel vast amounts of chemically rich material, before eventually exploding as a supernova.

On 7 December 2019 an Astronomer's Telegram (which these days is announced via email and Twitter) claimed that Betelgeuse was dimming. As Betelgeuse is a variable star it is not unusual to see variations in its brightness. However, on this occasion the brightness of Betelgeuse was continuing to fall far below that of what was expected and the dimming became so apparent that it was even noticeable by eye in the night sky.

Within two weeks of the telegram, our team, led by Dr Miguel Montargès, submitted a proposal and was granted time to observe Betelgeuse with the SPHERE (Spectro-Polarimetric High-contrast Exoplanet REsearch) instrument, among others, at the European Southern Observatory's (ESO's) Very Large Telescope (VLT) in Chile's Atacama Desert. The high angular resolution capabilities of SPHERE allow us to resolve the surface of Betelgeuse, which means that the star no longer looks like a point source and we can distinguish surface features. It was clear from the images we obtained on 27 December 2019 that there was a drop in brightness in the southern part of the star when compared to observations from January 2019.

But what could have caused this dramatic change? Much of the physics of red supergiants is still uncertain, so multiple causes are being explored. Our team is currently investigating two main theories; the fact that part of the surface is at a cooler temperature could be due to the convective activity of the star, or because a clump of dust has been ejected in our direction. This

CONSTANTINCORNEL/ISTOCK/GETTY IMAGES, ALLEXXANDAR/ISTOCK/GETTY IMAGES, NASA/JPL-CALTECH

Emily Cannon is an astrophysics PhD student from the Institute of Astronomy at KU Leuven in Belgium

dust theory would not be too unexpected as Betelgeuse has already been observed to have a clumpy outer wind, just like many other red supergiants. In order to test the viability of the theory that ejected dust is the cause, we are running many thousands of computer simulations that we can then compare to the observations.

Does this dimming mean Betelgeuse is about to go supernova? It is unlikely. The final nuclear reaction sequences that happen within the star have such short timescales that their light would not reach the surface before the explosion occurred, so we don't expect to see changes in brightness pre-supernova.

As we watch Betelgeuse regain brightness it is important to note that without the help of amateur astronomers in observing and documenting this star each day, much of this science would not be possible and events like this could be missed. Appearing on *The Sky at Night* is a fantastic opportunity to not only thank observers for their efforts, but also to encourage both the continued monitoring of Betelgeuse and other red supergiants, such as Antares, to help unravel the remaining mysteries of these stars. As we move through summer, I encourage everyone to use the nights to stargaze and to patiently wait for Betelgeuse to re-appear in the morning sky. How will it look?

Looking back: The Sky at Night

29 August 1981

On 29 August 1981's episode of *The Sky at Night*, Patrick Moore talked to meteor expert John Mason, who had recently returned from a trip to the south of France with 20 fellow astronomers from the South Downs Astronomical Society. Their mission – to record that year's Perseid meteor shower.

The group's goal was to monitor the shower not just during its peak, but in the days surrounding as well. To access as dark a sky as possible, the astronomers set up camp on a mountain plateau 1,500m above sea level in a remote part of Monts d'Aubrac in Lozère, 30km away from the nearest town.

▲ From a south of France location, observers logged over 2,500 meteors

By 9 August, three days before the peak, the crew had already logged 1,670 meteor sightings. But as the peak closed in, so did the clouds. The group made a mad dash to a site 150km away. Despite seriously damaging their van's exhaust during the race, they made it to the site by 2:30am and managed to record some 400 meteors before the dawn stopped the show. By the time it came for the astronomers to pack up and head home, they had logged over 2,500 meteors.

▸ See pages 26, 42, 64 and 68 for more information about this year's Perseids

Mars: a planet of wonder

This month, *The Sky at Night* takes a look at a planet that has fascinated us for centuries – Mars. Since the first probes flew past the Red Planet in 1965, the BBC has been reporting on every venture to Mars. In this episode, the team take a look through the archives and look at how our perception of the planet has changed over the last 50 years.

BBC Four, **9 August**, 10pm (first repeat BBC Four, **13 August**, 7:30pm)
Check www.bbc.co.uk/skyatnight for more up-to-date information

▲ *The Sky at Night* looks at our enduring fascination with the Red Planet

Emails – Letters – Tweets – Facebook – Instagram – Kit questions

INTERACTIVE

Email us at **inbox@skyatnightmagazine.com**

This month's top prize:
four Philip's titles

PHILIP'S The 'Message of the Month' writer will receive a bundle of four top titles courtesy of astronomy publisher Philip's: Ian Ridpath and Wil Tirion's *Star Chart*, Robin Scagell's *Guide to the Northern Constellations*, and Heather Couper and Nigel Henbest's *2020 Stargazing* and a planisphere for the night skies at latitude 51.5° north.

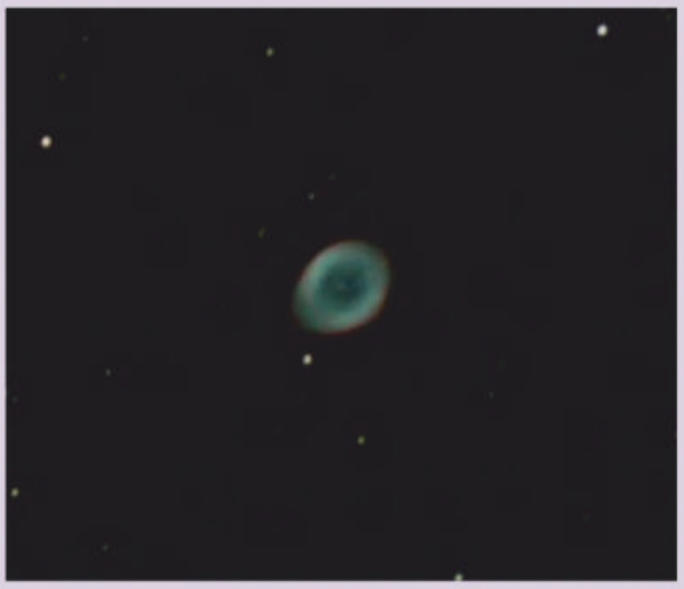
Winner's details will be passed on to Octopus Publishing to fulfil the prize

MESSAGE OF THE MONTH

Rising to the challenge

The 'Sky Guide Challenge' in July was to try to observe the central white dwarf star in the Ring Nebula, M57. I have just taken up the steep learning curve that is astrophotography and decided to have a go at imaging M57 as my very first target a couple of weeks ago. This is my finished result (right). I'm really pleased with my first effort, especially as I forgot just how small M57 appears in the eyepiece.

My setup was a Sky-Watcher 80ED on a Celestron AVX mount, with an unguided Canon EOS D500 DSLR camera controlled by APT on my laptop. I took 30 light frames, 20 darks and 40 bias (but no flats as I knew I'd need to heavily crop), stacked them in DSS and processed the final image in GIMP. I particularly like the colouration of this image and the fact that I can tick off this 'Sky Guide Challenge', as the central white dwarf is clearly visible.
Adrian Green, Rotherham



▲ **White dwarf visible: Adrian bags a wonderful image of M57**

Well done Adrian, that's a challenge you've more than met! It is indeed a nicely processed, the colour treatment particularly. ***– Ed.***

Tweets

Cath Adams
@CathAdams1973 • 23 June
@BBCStargazing Tonight's Crescent Moon setting at 22:38 taken with 8" Dobsonian & iPhone 7 Camera

Best of both worlds

I was interested to read that Katrin Raynor-Evans has combined her two hobbies of astronomy and philately ('Field of View', July). I have done something similar with numismatics, coin collecting. It started when I picked up a silver coin celebrating the life of Copernicus and from there I focused on a theme of coins with a celestial connection. Most astronomical events seem to have been celebrated with a coin or medallion of some sort. Eclipses and comets seem to be the most popular, the 1986 flypast of Halley's Comet being the most prolific. I also have one that depicts Columbus predicting a lunar eclipse to the indigenous people of Jamaica. Australia produced a series of domed coins depicting some of the Southern constellations (right). When the skies are cloudy I can open my coin trays and do some indoor astronomy.
Brian Beresford, via email

▲ **Celestial treasures: Brian combines his hobby of astronomy with coin collecting**

Night to remember

Firstly, I know that this is a terrible sunset picture (opposite page, top). So why am I sending it to you? I have reconnected with my boyhood love of the night sky while in

Joyful encounter: Ian's image of the Venus and Mercury conjunction

lockdown and found my binoculars that my parents bought me for my 13th birthday nearly 47 years ago. Seeing Mercury and Venus was very tempting and so, having had a few cloudy nights, I managed to get a clear view from on top of Sutton Bank in North Yorkshire. I went to see two planets and was surprised to first see the new Moon, then came Venus and – just as I was getting worried that Mercury would be blotted out by a bit of a haze – there it appeared. I captured the picture with my Panasonic DMC-FZ330 (a bridge camera not really suitable for night photography, and without a tripod) and processed it in Aurora. I also saw the ISS, a deer, an owl and a hedgehog. To see one of those would have been a thrill, to see them all in two hours was just wonderful. I'll never forget that evening and even have a terrible picture to remember it by!

Ian Haylett, via email

Stop Starlink

Having read your article 'Under a Starlink Sky' (June), I am utterly confounded as to how this 'attack' on our night sky was allowed to be carried out. To my mind it displays a disgraceful lack of responsibility; we all should challenge this and take steps to get it stopped.

Tony Noble, Warwickshire

A crater's age?

I enjoy Pete Lawrence's 'Moonwatch' articles in the Sky Guide, and find the fact box with essential details such as name, size, location and age useful. On that latter detail, could you tell me how the age of a Moon crater is calculated? ▸

ON FACEBOOK

WE ASKED: What is your most spectacular meteor memory?

Liz Calderwood Camping one night at Wolf Creek Crater, Australia we saw a huge ball of fire fall from the sky to Earth. We realised we had seen a fireball. We were treated to a fantastic display of shooting stars of all sizes, some fast and some slow, with long tails and short tails. Never to be forgotten.

John Hunt I spent a night in a tent in a cornfield on Bulbarrow Hill, Dorset in the 1970s and saw meteorites galore and the Milky Way so crystal clear. It created a wondrous memory of watching them with my late father that has lasted 44 years.

John Barry I went outside to see the ISS pass overhead and just as it was passing I saw a meteor going in the opposite direction. Here was science and nature putting on a show just for me.

Gillian Rushforth I was visiting Egypt with my husband and sons and we decided to climb Mount Sinai at midnight to reach the top for sunrise at 6am. The sky was so full of stars – I've never seen so many meteors criss-crossing the sky – it was magical!

Robert Weir I worked on an ice-strengthened ship going through the Northwest Passage a few years ago. I sat out on deck in the pitch black watching the Perseids when the sky started dancing. It's an amazing sight seeing the aurora – with Perseids seeming to fall through the coloured shimmering blanket into the sea.

SCOPE DOCTOR

Our equipment specialist cures your optical ailments and technical maladies

With **Steve Richards**

Email your queries to
scopedoctor@skyatnightmagazine.com

I currently have a Baader AstroSolar filter for my Sky-Watcher Skymax 127 Go-To scope and I want to step up my solar observing. Can I fit an H-alpha filter and what would I be able to see with it?

JESSICA PRICE

▲ A Daystar Quark eyepiece might be an option

The AstroSolar filter that you are using will give excellent white light views of the Sun, showing sunspots and granulation. However, installing a Hydrogen-alpha (Ha) astro imaging filter will not allow you to see detail on the Sun such as loops and prominences. Instead, solar astronomy requires a piece of equipment called an 'etalon', which focuses in on an extremely narrow band of wavelengths; confusingly, these are often referred to as H-alpha filters as well.

Etalons are found in solar telescopes like those made by Coronado, Daystar or Lunt, and also come as separate units that can be fitted to the front of refractor telescopes to be used with an energy rejection filter (ERF) and a blocking filter, which require specialist engineering techniques to install. Unfortunately, your scope design, a Maksutov-Cassegrain, is unsuitable for these options; to observe or image solar loops and prominences, you would need to buy a solar scope or a refractor. Daystar also makes an H-alpha etalon eyepiece called a Quark and, provided you use a suitable ERF installed on the front, you could use one with your Maksutov-Cassegrain.

Steve's top tip

How do I work out the magnification of my eyepiece?

The magnification of an eyepiece is dependent on the focal length of the telescope that it is used with. Scopes with longer focal lengths provide greater magnification with a given eyepiece than those with shorter focal lengths. Conversely, eyepieces with shorter focal lengths provide greater magnification with a given telescope than longer focal length eyepieces.

You can work out the magnification of a telescope and eyepiece combination by dividing the focal length of the scope by the focal length of the eyepiece. An eyepiece with a focal length of 25mm used in a scope of 500mm focal length will have a magnification of 500 ÷ 25 = 20x.

Steve Richards is a keen astro imager and an astronomy equipment expert

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Tweets

Rhidian Rees
@RhidianR • 22 June
Our turn for some #ISS action in the Southern Hemisphere. Spotted over #Trelew in #Patagonia @butchschlong40 @VirtualAstro @skyatnightmag @beatnurotic @DavidBflower @xandaolp @andy_stones

▸ It would be an interesting topic for my astronomy club.
Robert Bridges, via email

The relative ages of craters can be arrived at by determining which younger craters overlap older features; and then combined with dating samples returned by Apollo missions, and temperature data from the Lunar Reconnaissance Orbiter. ***– Ed***

Summer sights...

Staring through a field of wheat, swaying in the summer breeze, eyes fixed on a waxing gibbous pre-strawberry Moon; bathing in the solar rays of our very own glowing ball of hydrogen and helium; reading Carl Sagan and contemplating the everything of it all; listening to the sweet but somewhat sinister jazz tones of *Monorails and Satellites* by Saturn descendent Sun Ra; and spotting a silver speck in the cloudless blue sky, watching it wobble and bobble for an age, far in the distance, thinking it's probably a weather balloon, but it *could* be a UFO.

I'd been getting frustrated by the lack of dark skies and stargazing time at present, but your 'Daytime Astronomy' feature (July) really helped me put a different spin on things. Now the cheap old binoculars live in my sunbathing bag!
Paul Ackroyd, Wood Green

CORRECTIONS

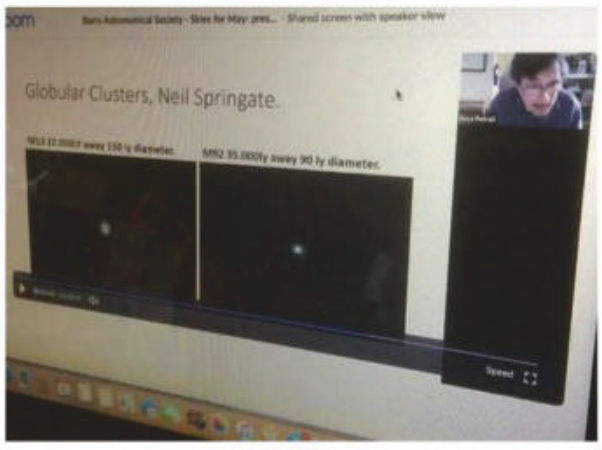
In April's 'Astrophotography Gallery', Karl McCluskey's image of the Jellyfish Nebula was accompanied by the wrong caption. The photo and correct caption is included in this month's Gallery on page 75.

SOCIETY IN FOCUS

Barry Astronomical Society was formed in 2016 by Dave Powell as a result of his investigations into a society of the same name that had existed in the early 20th century, but had faded away shortly after the First World War. Dave's research reignited an interest in restarting the society among local amateur astronomers and historians and so – 100 years after its first incarnation – Barry's Astronomical Society was inaugurated again.

We usually meet at 7:30pm on Mondays, once a fortnight in Barry Island Community Centre, and we recently welcomed our 60th member. Meetings include a guest speaker, often from Cardiff University's Department of Physics and Astronomy, or from other astronomical societies from South Wales and beyond.

Observing sessions are held at nearby Amelia Trust Farm and Porthkerry Country Park. The latter has a Forest Lodge where we hold outreach sessions. In July 2019 we celebrated the Apollo 11 Moon mission with an observing session from a grassed area near our meeting



venue on Barry Island. It was the night of the partial lunar eclipse and we had a view overlooking the Bristol Channel, giving passers-by views of the eclipse through giant binoculars and wowing them with the sight of Saturn and Jupiter.

Face to face meetings and group observing sessions haven't been possible in lockdown so we are keeping members informed and entertained with live-streamed video talks (above) on our website, which also has a growing gallery of astro images sent in by our members.
Thomas Easton, society secretary and newsletter editor
▸ www.barryastronomical.wordpress.com

COVID-19

How to get your astro fix from your own home

We pick the best astronomy events and resources available online this month

WHAT'S ONLINE

ONLINE TALKS

UK Goes to the Moon

Libby Jackson, human exploration programme manager for the UK Space Agency, talks about the UK's role in building technology for a return to the Moon.

bit.ly/Libbyjackson

PODCAST

The Space Above Us

A lively, fact-packed look at every crewed NASA spaceflight, from Mercury to the Space Shuttles and everything in between, with JP Burke from NASA.

http://thespaceabove.us

RADIO

The Food Chain: Made in Space

How studying plant growth in space – with low gravity and little or no natural light – may revolutionise food production on our increasingly populous planet.

www.bbc.co.uk/sounds/play/w3csyp1n

Witness History: A Space Crash

The British astronaut on board a supply vessel that crashed into the Mir space station in 1997 gives a first-hand perspective of what is the worst collision in the history of manned space flight.

www.bbc.co.uk/sounds/play/w3cszmtq

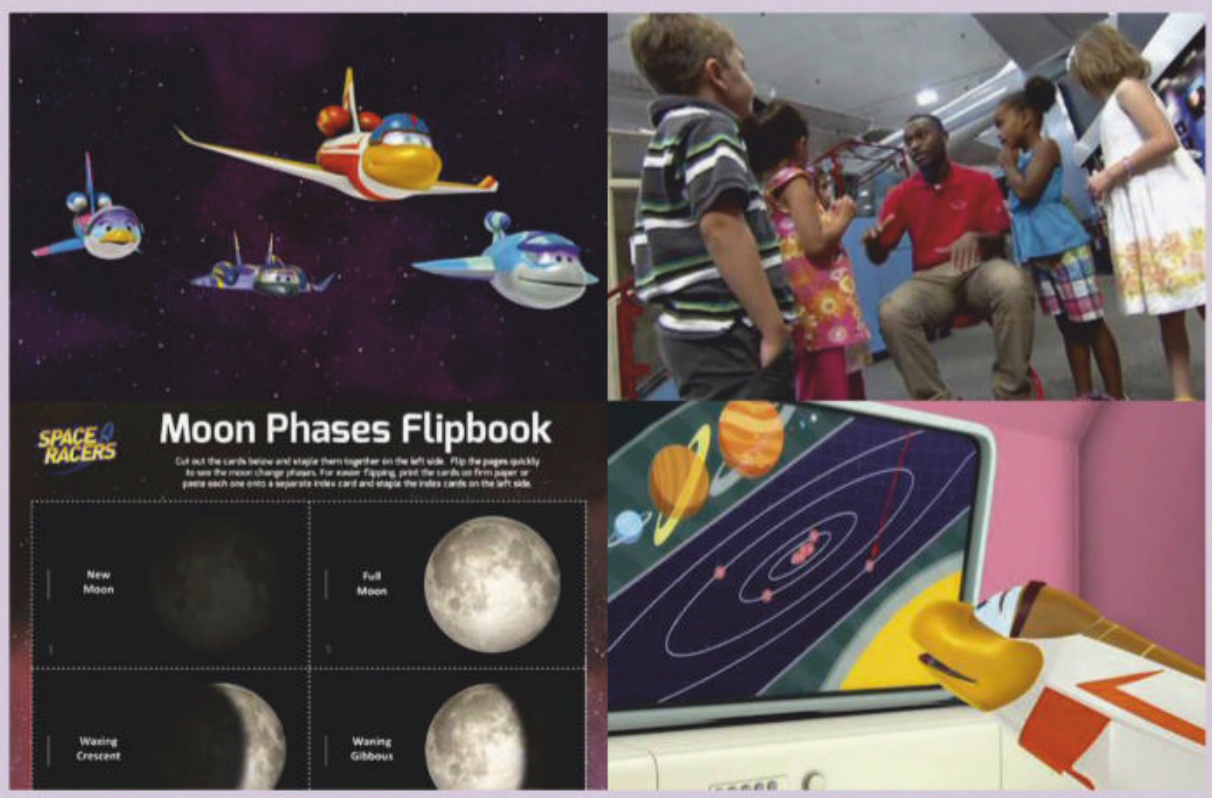
ONLINE COURSES

Astronomy: Exploring Time and Space

Get a grounding in all things astronomy, with this free 44-hour online course, including lecture videos, quizzes and some written assignments.

www.coursera.org/learn/astro

PICK OF THE MONTH



▲ Counting down to adventure: an entertaining show that's packed with real space science

Space Racers

Fun space-themed activities for preschoolers to 11 year olds

Parents of young children may already know the animated kids TV show *Space Racers* from Youtube or Netflix. It is produced in collaboration with NASA experts and follows Eagle, Robyn, Hawk, Starling and the cadets of Stardust Space Academy as they explore the Solar System. Each programme layers real space science into the stories and features catchy songs about topics such as gravity, the constellations and the Sun.

Now there are free printable *Space Racers* activities online, from monthly space-focused calendars and constellation colouring sheets to singalong lyrics and planetary matching games. For all those lockdown parents-turned-teachers there are also great STEM-focused lesson plans, pitching subjects like heliophysics, Earth science, planetary science and astrophysics at a level suitable for preschool to Key Stage 2 (up to the age of 11). You'll find resources focused particularly on the Moon and NASA's Mars InSight mission too, for youngsters keen to go a bit deeper.

www.spaceracers.com

CITIZEN SCIENCE

Disc detectives wanted

Join the hunt for new circumstellar discs, where new planets are born, by comparing NASA's Wide-field Infrared Survey Explorer (WISE) images with data from other space surveys.

bit.ly/Discdetective

Spiral Graph project

Trace the spiral arms that you see in galaxy images – and learn how to measure their 'pitch angles' – as part of a useful project to help scientists find interesting candidate galaxies for future study.

bit.ly/Spiral-graphproject

FIELD OF VIEW

All under the same sky

In light of the Black Lives Matter movement, the barriers that hold back diversity in astronomy and geophysics need to be addressed

Planetary scientist and author **Dr Sheila Kanani** is the education, outreach and diversity officer at the Royal Astronomical Society

As a British-Indian woman, growing up, I sometimes felt a bit awkward about my career path into the space industry. I was often surrounded by doctors, dentists and pharmacists, and the elder generation didn't understand why I might want to pursue a career in astrophysics.

Today, I hope to inspire young people from all backgrounds to pursue a career in astronomy or geophysics, regardless of ethnicity, gender or social mobility. I work with the Committee on Diversity in Astronomy and Geophysics (CDAG) at the Royal Astronomical Society (RAS) and other organisations to study and improve diversity, but this is no mean feat.

One of the defining features of space and astronomy is that it should be accessible to everyone. We are one human race, on one planet, all looking up at the same sky. However, the people involved in astronomy and geophysics are overwhelmingly white, male and from the older generation. There are very few realistic role models for black students, and when it comes to the opportunity for Black, Asian and minority ethnic (BAME) young people to continue into further education and academia, there is a broken pipeline.

While there is some representation of minority ethnic scientists in our field, there are almost no black British astronomers in the UK. The last demographic survey from the RAS in 2016 shows that 95 per cent of British respondents were white, compared with 87 per cent of the general population, and out of 903 respondents only one identified as black and British.

Family has a significant impact on the career choices of BAME children. Vocational careers are thought of more favourably, and a degree in physics often isn't given the same significance as a career in medicine or accounting.

At the RAS we don't want to speak on behalf of the BAME community or assume what this community needs or wants, but we also don't want to lay the burden at their feet. However, that doesn't mean we are doing nothing.

Over the last few years at the RAS we have run one-off events with charities like Generating Genius and the Reach Foundation, and organisations such as Black British in STEM and the Institute of Physics. We held a nationwide screening of *Hidden Figures* for black and non-white school children (mostly girls), and had over 400 students take part. We regularly participate in Black History Month and we have presented posters showcasing black astronomers and geophysicists in history. But we need to do more.

Our goal is to inspire more young people from BAME backgrounds to undergo STEM (science, technology, engineering and mathematics) learning, and we have created a plan for engaging with more black astronomers and geophysicists. Action points include: a call out to our members (Fellows) for black Fellows to get more involved in our work, including joining CDAG; a call for more nominations from BAME researchers, showcasing black astronomers and geophysicists across the globe; and working with funding councils to fix the broken pipeline in the space industry.

Not only do we want to understand why these challenges and barriers exist, but we want to ensure that no future astronomers feel unwelcome in our field. After all, we all share the same sky and planet, no matter where we're from or the colour of our skin.

NADIA BORMOTOVA/ISTOCK/GETTY IMAGES

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BBC Sky at Night MAGAZINE

Bright ideas: you still stand a chance of seeing the Perseids this month, but there are also many other attractions to see in the night sky

Perseid NIGHTS

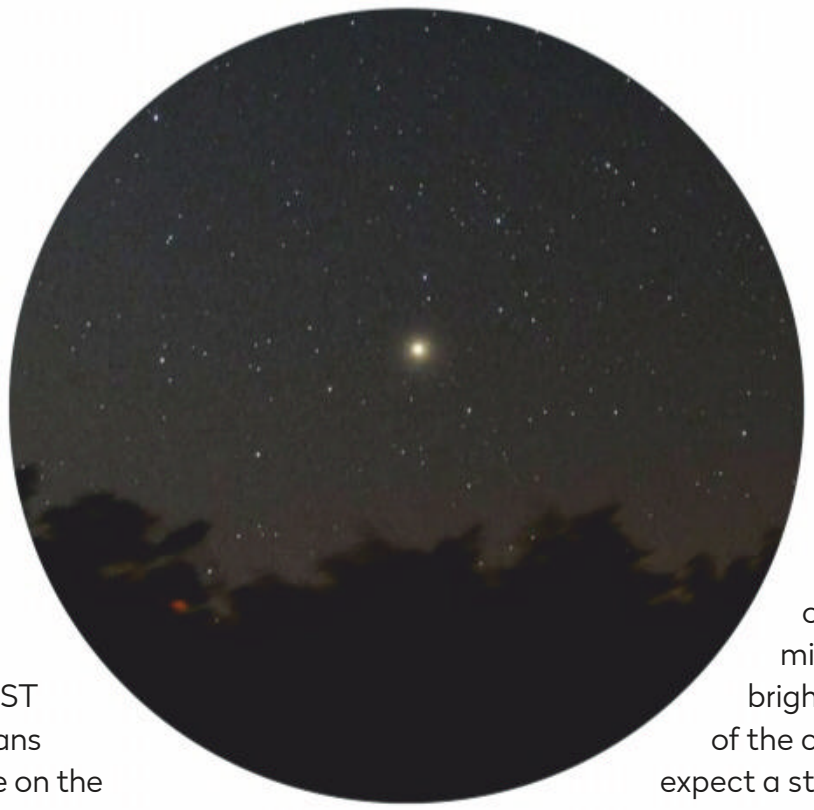
August's peak of the Perseid meteor shower is likely to be affected by the Moon this year, so **Stuart Atkinson** selects some other targets to look out for

There's something of an annual stargazing ritual. In the same way that many of us go through the Christmas *Radio Times*, circling the films and TV specials we want to watch, at the start of every year amateur astronomers check the observing prospects for eclipses, comets and the planets during the months to follow. They also want to know how the major meteor showers will be affected by the Moon, especially the best shower of the year, the Perseids, which peaks in mid-August.

Guides to 2020 advised us that this would be a challenging year for Perseid watchers, when a last quarter Moon will be close to the shower radiant over the peak period. This means that fainter Perseids won't be seen, and we'll have to wait longer between meteors that are bright enough to see. It doesn't have to be a bad thing however, as it means there'll be plenty of time to enjoy observing other things.

Although the Moon will affect this year's Perseid meteor shower, that doesn't mean you should just forget about it and stay in bed. There will still be more shooting stars than usual skipping across the sky, ▸

DANIEL DAMASCHIN/ALAMY STOCK PHOTO



◂ Red Planet rising: keep a look out for Mars as it rises from the eastern horizon on 12 August

▸ some of them very bright and colourful, and some could leave ghostly glowing trails behind them too. The Perseid peak is on 12 August, but estimated to be between 14:00–17:00 BST (13:00–16:00 UT). This means heightened activity will be on the night of 11/12 August (the rise to the peak) and 12/13 August (the fall from the peak).

You'll be able to see some Perseids from your garden on the night of the 12 August, but to enjoy the shower at its best you'll need to find a more favourable observing location, somewhere not affected by light pollution. It's a good idea to scout about in advance for such a location, so you're not driving about on the night.

Before heading out to watch the Perseids, make sure you're dressed for a long night – with a warm jacket, gloves, hat and scarf – and have a hot drink and snacks to sustain you. If you don't have any other meteor watchers for company, take a radio to keep you awake. Don't sit on a wall, you'll feel cold and damp creeping through you in no time; a deck chair or reclining chair will be much more comfortable. Be at your site by 22:30 BST (21:30 UT) and allow your eyes time to adapt to the darkness. Once you've achieved dark adaptation, don't look right at Perseus; you'll see more meteors if you look away from the radiant, off to either side of it or above it instead. Then... look up and wait.

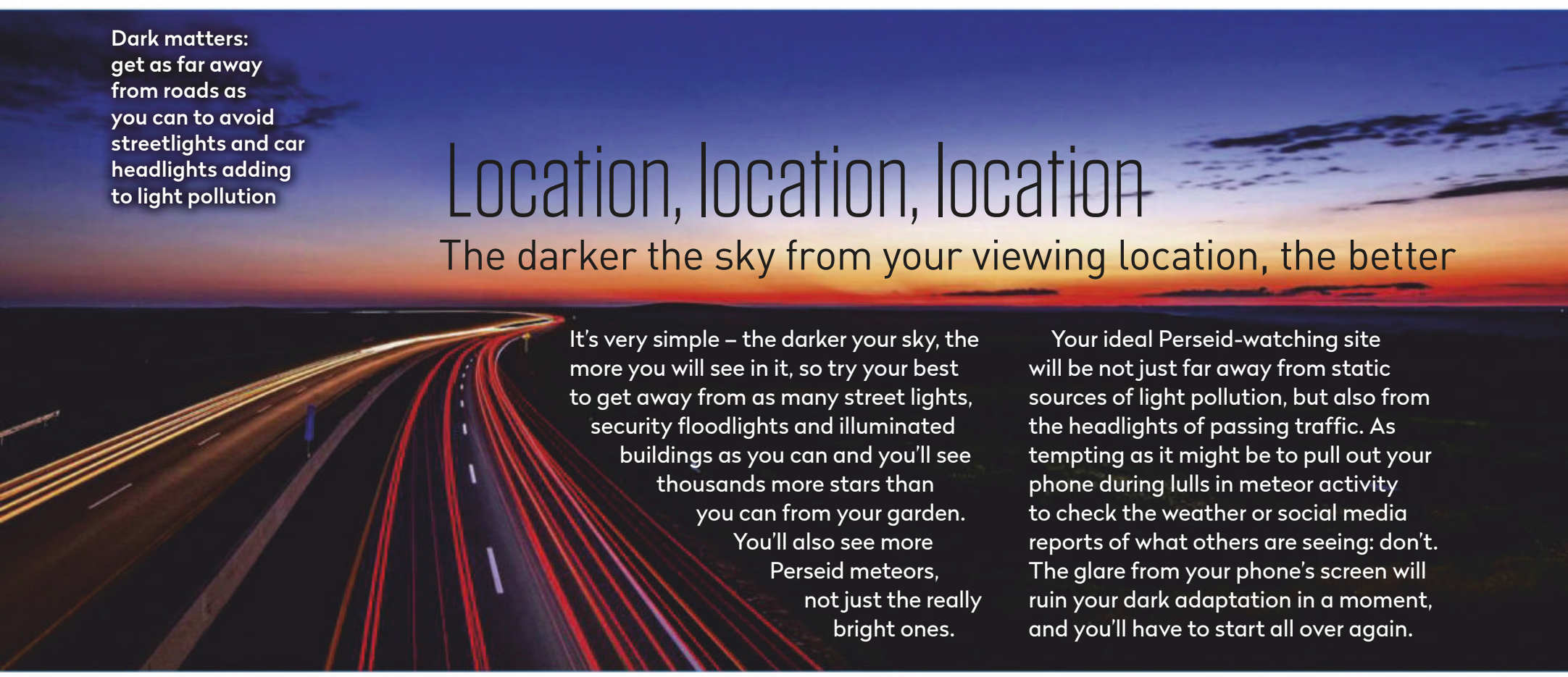
How many meteors can you expect to see? Well, theoretically, one every minute or so, but realistically you'll spot one perhaps every five minutes. Some will be very bright, others just glimpsed out of the corner of your eye. Don't expect a steady stream of shooting stars; there'll be long periods when you see none, followed by exciting flurries of activity. The trick is to just settle down and wait. And when you start yawning and that voice starts whispering in your ear, "Go home... the best is over... you need to sleep..." don't give in. Stay out as long as you possibly can, because activity will be at its greatest in the hours before dawn.

While waiting for Perseids it's the ideal time to enjoy looking at other things in the sky – and this year there will be a lot of fascinating ones to see. Here are some suggestions for other targets to search out, in between shooting stars.

A parade of planets

If your Perseid observing site has a flat, low horizon from the northeast to the south, you'll be able to enjoy looking at a planetary parade while you wait for meteors to skim across the sky. On the evening of 12 August the show starts with Mars rising in the east around 22:45 BST (21:45 UT). Shining

PETE LAWRENCE X 3, MARK ALEXANDER/ISTOCK/GETTY IMAGES



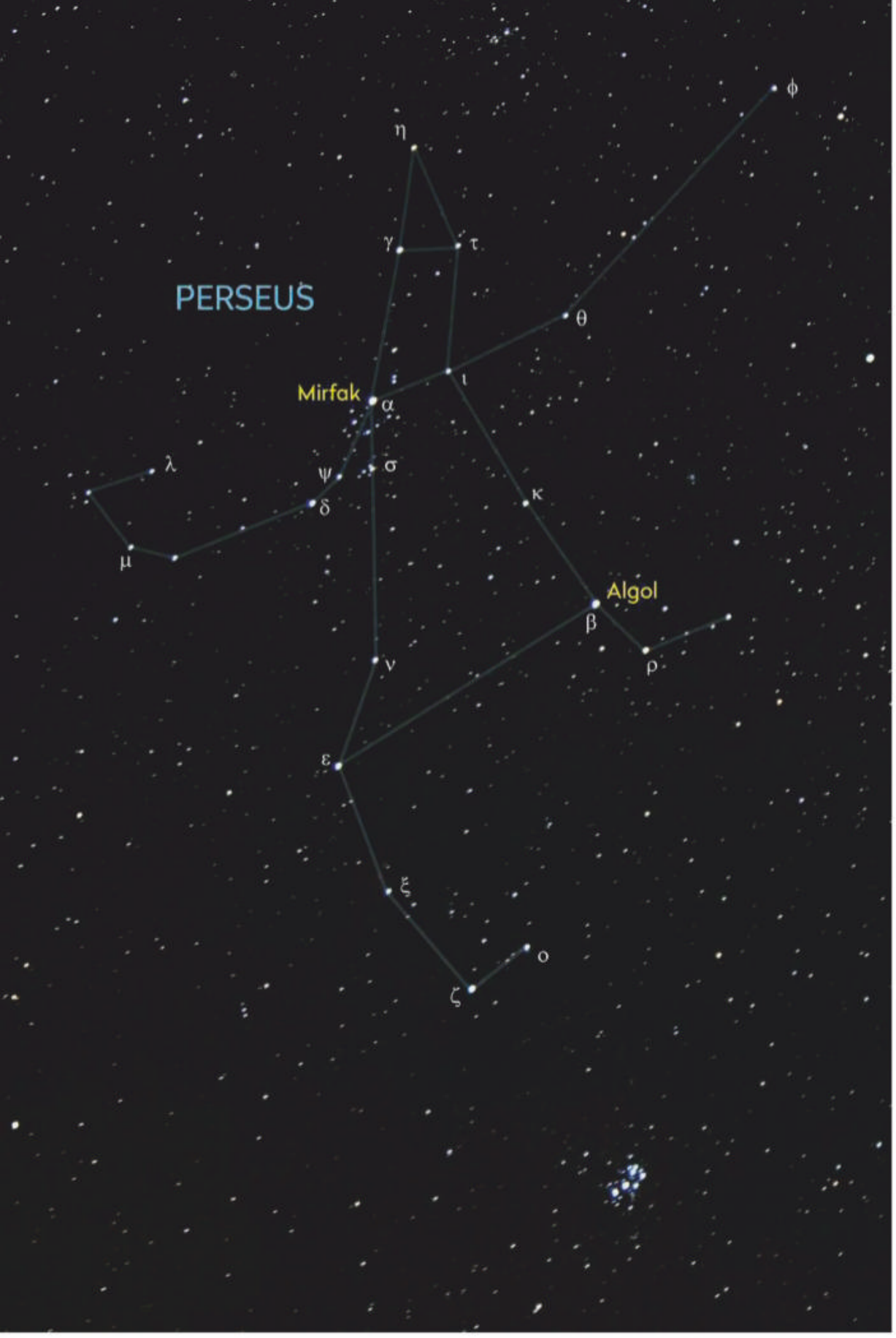
Dark matters: get as far away from roads as you can to avoid streetlights and car headlights adding to light pollution

Location, location, location

The darker the sky from your viewing location, the better

It's very simple – the darker your sky, the more you will see in it, so try your best to get away from as many street lights, security floodlights and illuminated buildings as you can and you'll see thousands more stars than you can from your garden. You'll also see more Perseid meteors, not just the really bright ones.

Your ideal Perseid-watching site will be not just far away from static sources of light pollution, but also from the headlights of passing traffic. As tempting as it might be to pull out your phone during lulls in meteor activity to check the weather or social media reports of what others are seeing: don't. The glare from your phone's screen will ruin your dark adaptation in a moment, and you'll have to start all over again.

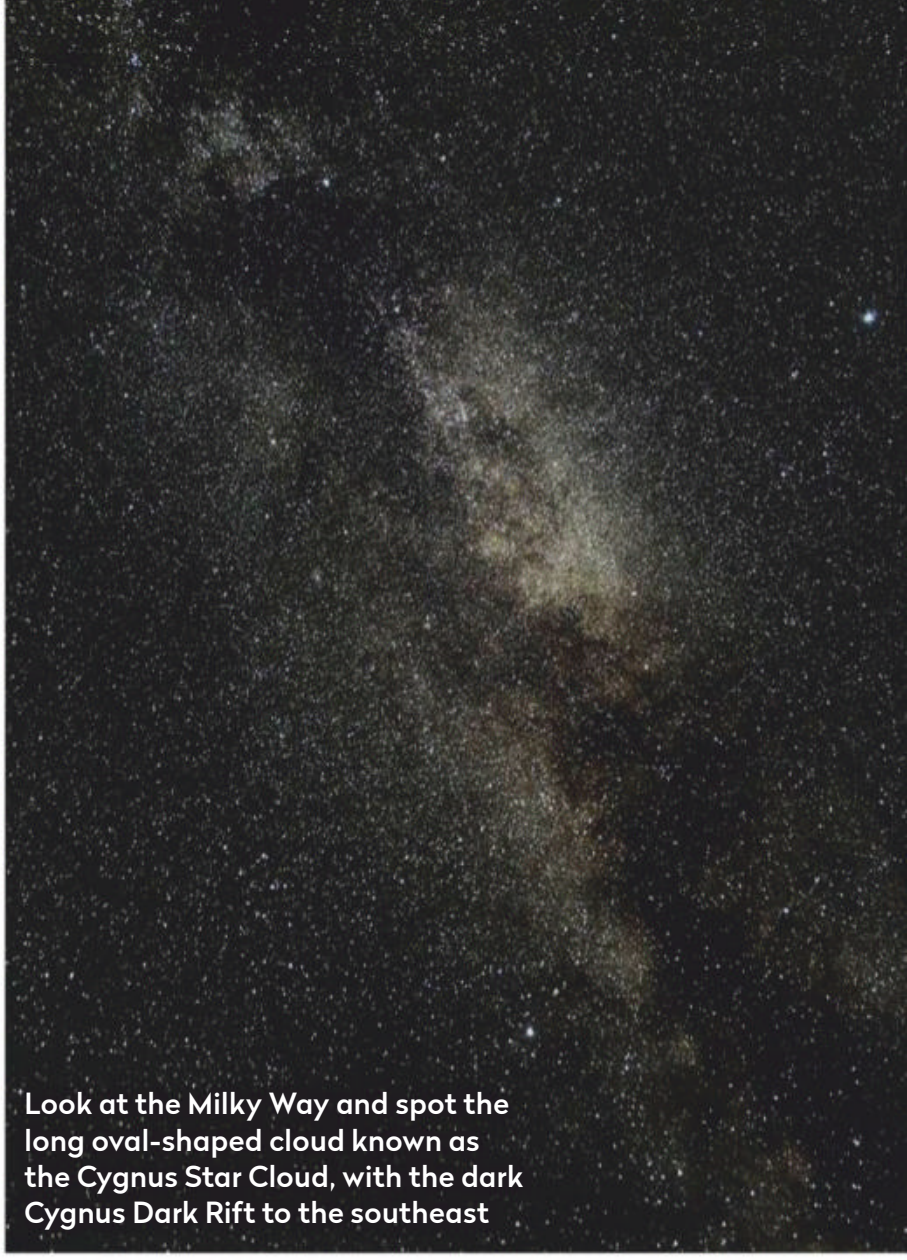


▲ **The constellation of Perseus gives the Perseids its name. It's the location of the shower's radiant – the location that its shooting stars appear to come from – during peak activity**

impressively at around mag. –1.3 it will be very obvious to the naked eye, looking like a bright orange spark. Binoculars will enhance both its brightness and its glorious colour, and a telescope will show you its ochre disc, perhaps even its bright, icy south pole and dark features on its surface. It will dominate the evening sky in a couple of months.

Having found Mars, turn right until you are facing south, where you'll see what look like two bright stars in the sky. These stars are actually two more planets. The brighter of the two will be Jupiter, with fainter Saturn just to its left. Binoculars won't show you Saturn's famous rings but you might make out its largest moon, Mercury-sized Titan, as a tiny star close on its right. Binoculars can also show you Jupiter's four largest moons and, if you have a telescope with you, Jupiter's yellow-white disc, crossed by bands of toffee-hued cloud, will be a lovely distraction during lulls in meteor activity.

Planets spotted, what else can you look at during the quiet periods of the meteor shower? How about a trip along the Milky Way? To begin, look towards the northeast where you'll see a bright, yellow-white star twinkling away down near the



Look at the Milky Way and spot the long oval-shaped cloud known as the Cygnus Star Cloud, with the dark Cygnus Dark Rift to the southeast

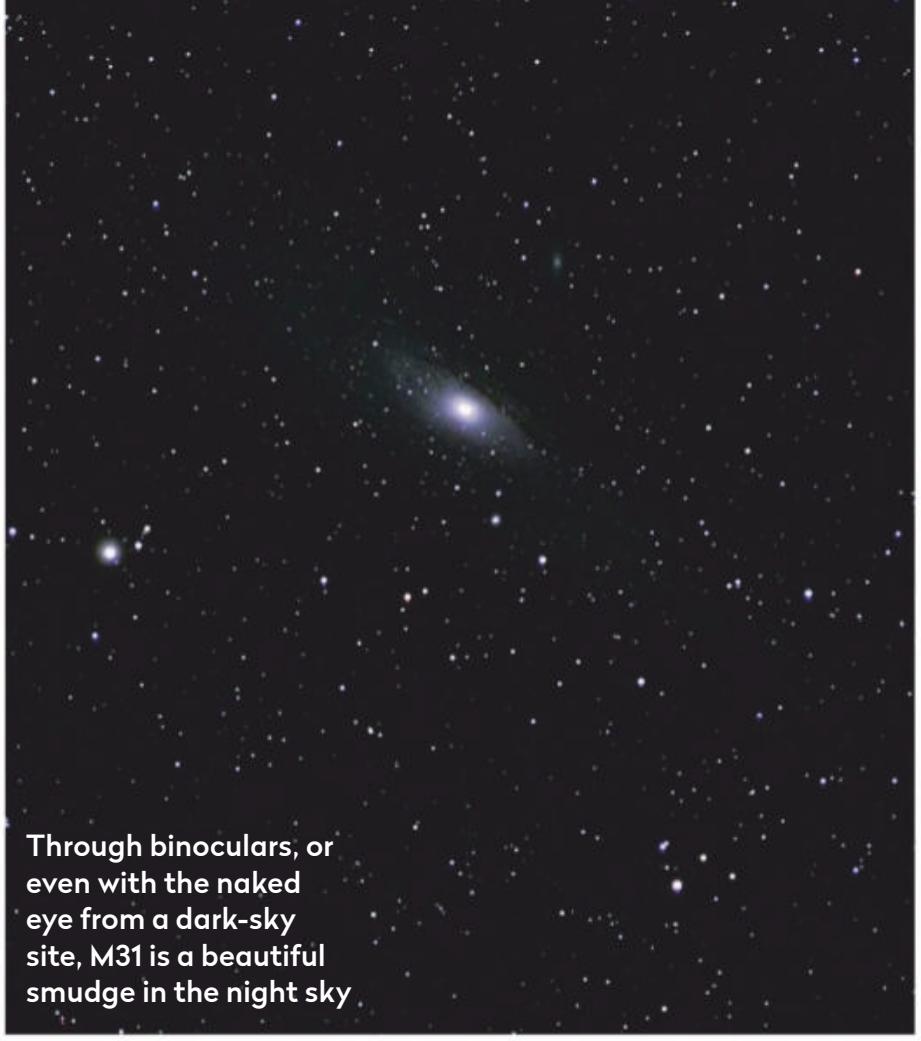
horizon; this is Capella. A giant star, Capella is almost 43 lightyears away and is the closest first magnitude star to the celestial north pole: at mag. +0.08 it's the sixth brightest star in the sky.

To Capella's upper right you'll see a pattern of stars that might remind you of a wishbone from a cooked chicken or even a pair of garden shears. This is the constellation of Perseus. The Perseid meteor shower is named after this constellation because its shooting stars appear to zip away from it during peak activity. You might recognise heroic Perseus from fantasy films, hacking the serpent-haired head off Medusa and riding his winged horse, Pegasus, across the sky.

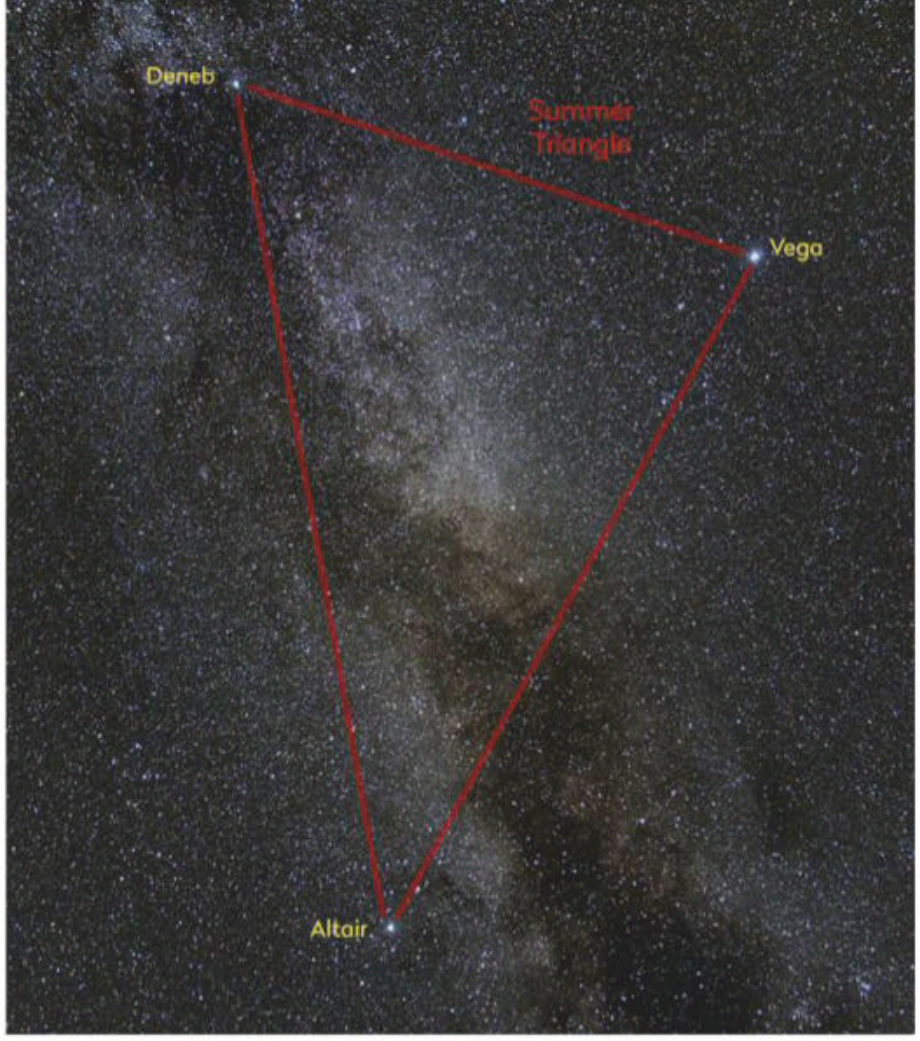
Double beauty

Directly above Perseus you'll see a very distinctive pattern of five stars in the shape of a W. We'll come back to that. For now look roughly halfway between that W and Perseus: you're looking for a misty smudge, more obvious if you look slightly to one side of it. This is a famous deep-sky object called the Double Cluster, a pair of beautiful, glittering star clusters, each containing thousands of stars. Although they appear to be side by side, the clusters are hundreds of lightyears apart.

Back to that W of stars. This is the constellation of Cassiopeia – representing a vain queen who was tossed into the heavens by the Greek gods for foolishly declaring she was more beautiful than any of them – and it can guide you to one of the best-loved deep-sky objects of all. If you split the W into two Vs the highest one points like an arrowhead to a small smudge. This is M31, the Andromeda Galaxy, a spiral galaxy around 2.5 million lightyears away that's roughly twice the size of our Milky Way. It's the most distant object the naked eye can see. Under a dark sky a pair of binoculars transforms that smudge into a misty oval, glowing with the combined light of a trillion distant suns. ▸



Through binoculars, or even with the naked eye from a dark-sky site, M31 is a beautiful smudge in the night sky



▲ **The Summer Triangle is made from three of the brightest stars in the sky: Deneb, Altair and Vega**

PETE LAWRENCE, STEPHEN CHUNG/ALAMY STOCK PHOTO, CHART BY PETE LAWRENCE, ROBERT SCHULZ/CCDGUIDE.COM

▸ Next, look almost overhead for what looks like a long, oval-shaped cloud there, almost as if someone has smudged chalk dust on the sky with their fingertip. This is the Cygnus Star Cloud, a region in the Milky Way so densely packed with stars that it looks like a cloud of smoke to the naked eye, but is resolved into countless stars through binoculars.

To the southeast of the Cygnus Star Cloud is a dark area, which looks as if someone has plucked all the stars out of the Milky Way. This is the Cygnus Dark Rift and it appears dark because clouds of dense interstellar dust are blocking our view of the stars in that direction.

Spotting the Summer Triangle

Neatly framing that bright star cloud and the dark rift running down along its side is a triangle of three bright stars. Deneb, Altair and Vega are known collectively as the Summer Triangle and are three of the brightest stars in the sky, shining at mag. +1.3, mag. +0.93 and mag. 0.0 respectively. Altair and Vega are both less than 30 lightyears distant, but Deneb is an incredible 2,600 lightyears away. About 200,000 times more luminous than our own Sun, Deneb is a true giant of a star and was the Pole Star 18,000 years ago. Due to the precession or wobbling of Earth's axis it will be an approximate Pole Star again around the year 9800 AD.

Although the Summer Triangle is very distinctive, it's not equilateral. If you look to Vega's lower right you'll see another star, Rasalhague, which is only second magnitude and this can be connected with Vega and Altair to form an equilateral triangle shape.

Below Rasalhague, down towards the horizon the Milky Way grows thicker and more clotted behind a pattern of stars that looks like a teapot or even a genie's lamp. This is part of the constellation of Sagittarius, and it is crowded with fascinating deep-sky objects. Unfortunately, this part of the Milky Way never climbs very high in the northern sky, but if you sweep it with

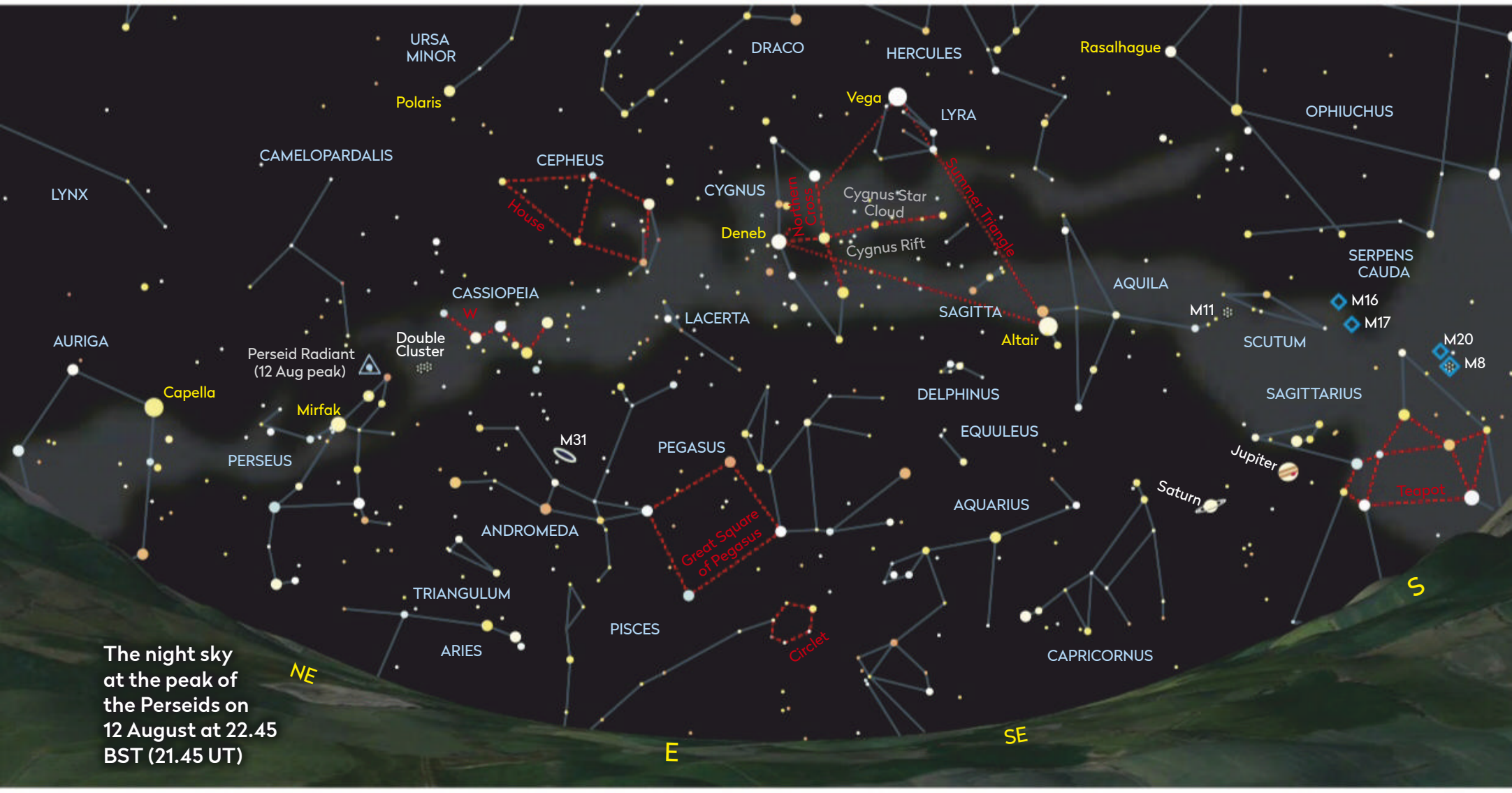
The ISS and other satellites

Your meteor watch will also reveal many human-made stars

Through the night you will regularly see a point of light moving slowly across the sky. This will be one of the thousands of artificial satellites orbiting the Earth. Some will appear as bright as the stars of the Plough, others will be so faint you will barely see them and some might flare briefly, becoming strikingly bright before fading from view.

The International Space Station (ISS) can appear very bright in the sky sometimes, but it won't be visible during the Perseids. If you see a number of satellites moving across the sky in a trail like railway carriages, they will be some of the many hundreds of SpaceX Starlink satellites now in orbit. Many professional astronomers are greatly concerned that as these satellites fill the sky they will ruin their work, while amateurs are frustrated by their impact on astrophotography and the natural beauty of the heavens.

Train of lights: the SpaceX Starlink satellite megaconstellation may be visible



▲ Summer heights: look out for the W-shaped Cassiopeia, the Summer Triangle, the Teapot in Sagittarius and so much more

Just be content to stand there in the dark and wait for shooting stars to start skipping across the sky. Even with the Moon there you'll be in for a treat

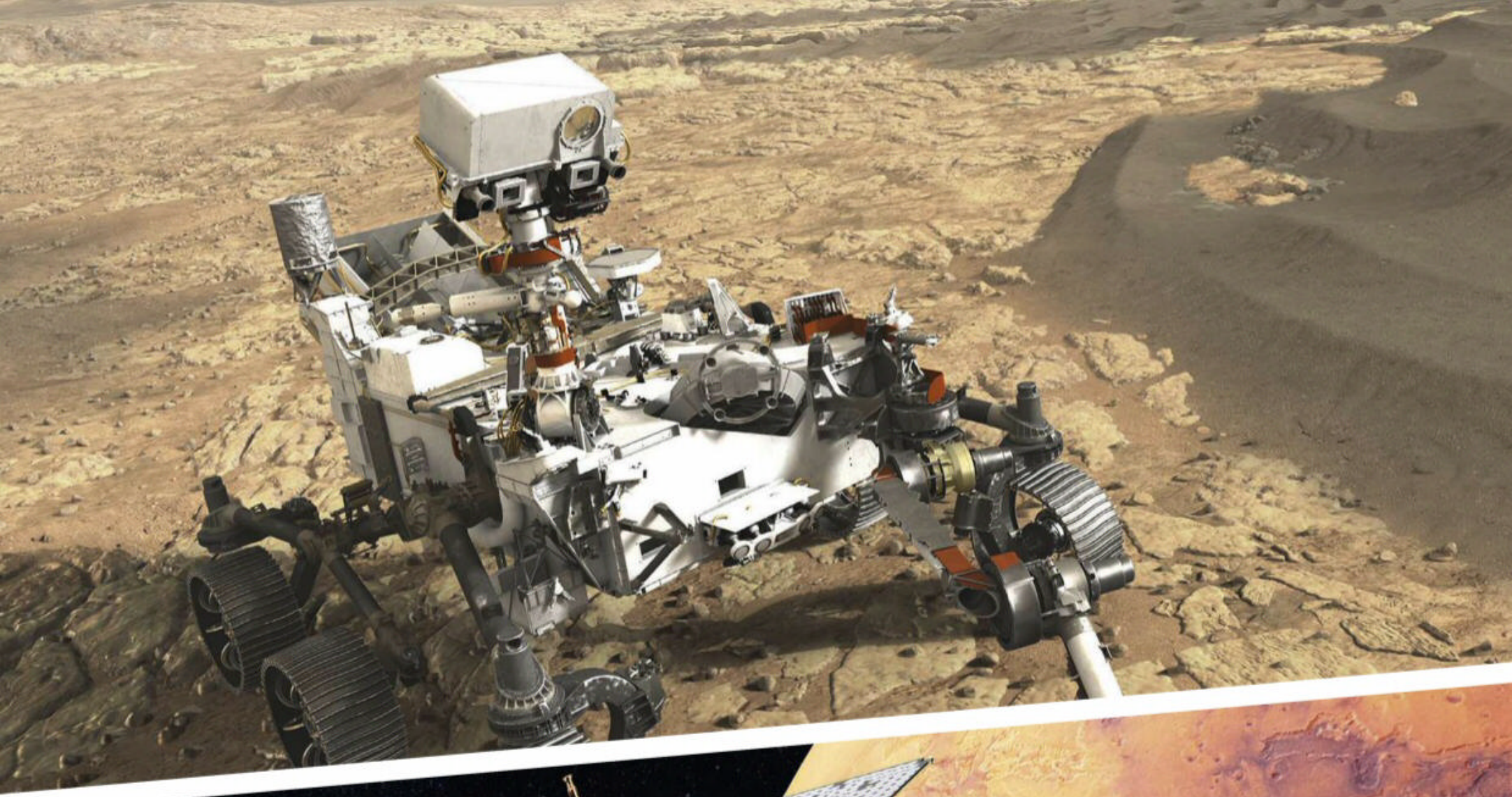
Stuart Atkinson is a lifelong amateur astronomer, public outreach educator and author of nine books on astronomy and spaceflight

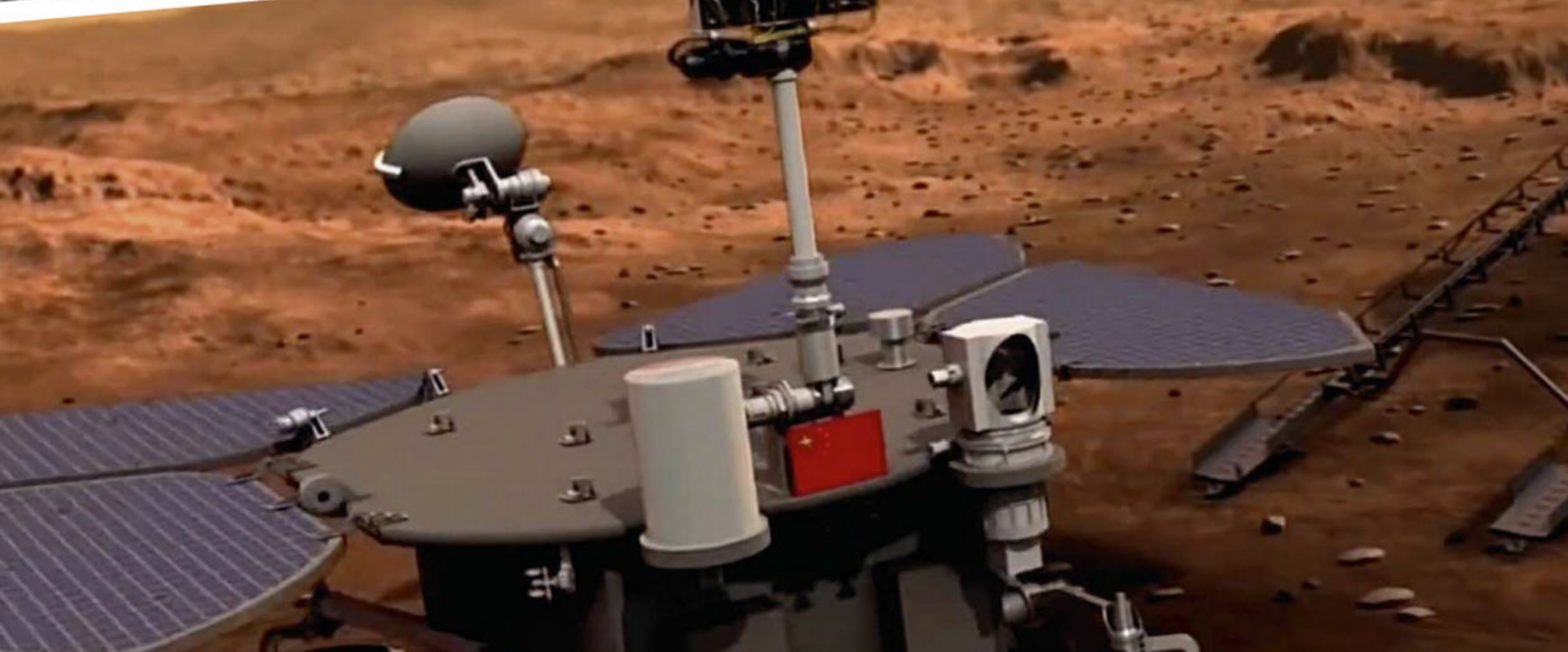
binoculars you'll see a subtle brightening if under dark skies. It's a region that contains nebulae, glittering star clusters and simply too many background stars to count. This is the location of famous deep-sky objects such as the Omega Nebula, M17, the Lagoon Nebula, M8, the Trifid Nebula, M20 and the Wild Duck Cluster, M11. Use our chart (above) to find them – and imagine how stunning they would look from the Southern Hemisphere, where they'd be much higher in the sky.

Our fascinating tour concluded, turn your gaze east and you'll see the sky brightening in that direction in advance of the Moon rising – at 23.50 BST (22:50 UT) on the night of the 11/12 August and 00:10 BST (23:10 UT) on the night after. There's lots to see on the Moon through binoculars, but on these nights the brilliance of its last quarter phase will ruin your dark adaptation. For now, just be content to stand there in the dark and wait for shooting stars to start skipping across the sky. Even with the Moon there you'll be in for a treat – and almost certainly a few jaw-dropping moments too.

▶ For more on the Perseids see pages 42, 64 and 68

Deep-sky gems: the Trifid (top) and Lagoon Nebulae are among the deep-sky wonders in Sagittarius





◄ **Missions to Mars: NASA's Perseverance (top), the UAE's Hope (middle) and China's Tianwen-1 (bottom) are all scheduled to launch this summer**

ILLUSTRATION

Earth's armada TO MARS

As three spacecraft make their way towards the Red Planet, **Govert Schilling** examines what they hope to achieve

On Thursday 18 February 2021, with protection from a heat shield and 20m-wide parachutes, NASA's Perseverance rover is scheduled to descend through the thin Martian atmosphere. Minutes later, the six-wheeled machine will be lowered to the Red Planet's surface from a sky crane that is hovering at low altitude.

Perseverance will not be alone. Around the same time the UAE's Hope spacecraft will enter the orbit of Mars to study the planet's atmosphere and climate; and a few months later the lander part of the Chinese Tianwen-1 mission will touch down elsewhere on the Red Planet, releasing its own miniature rover to explore the desert world.

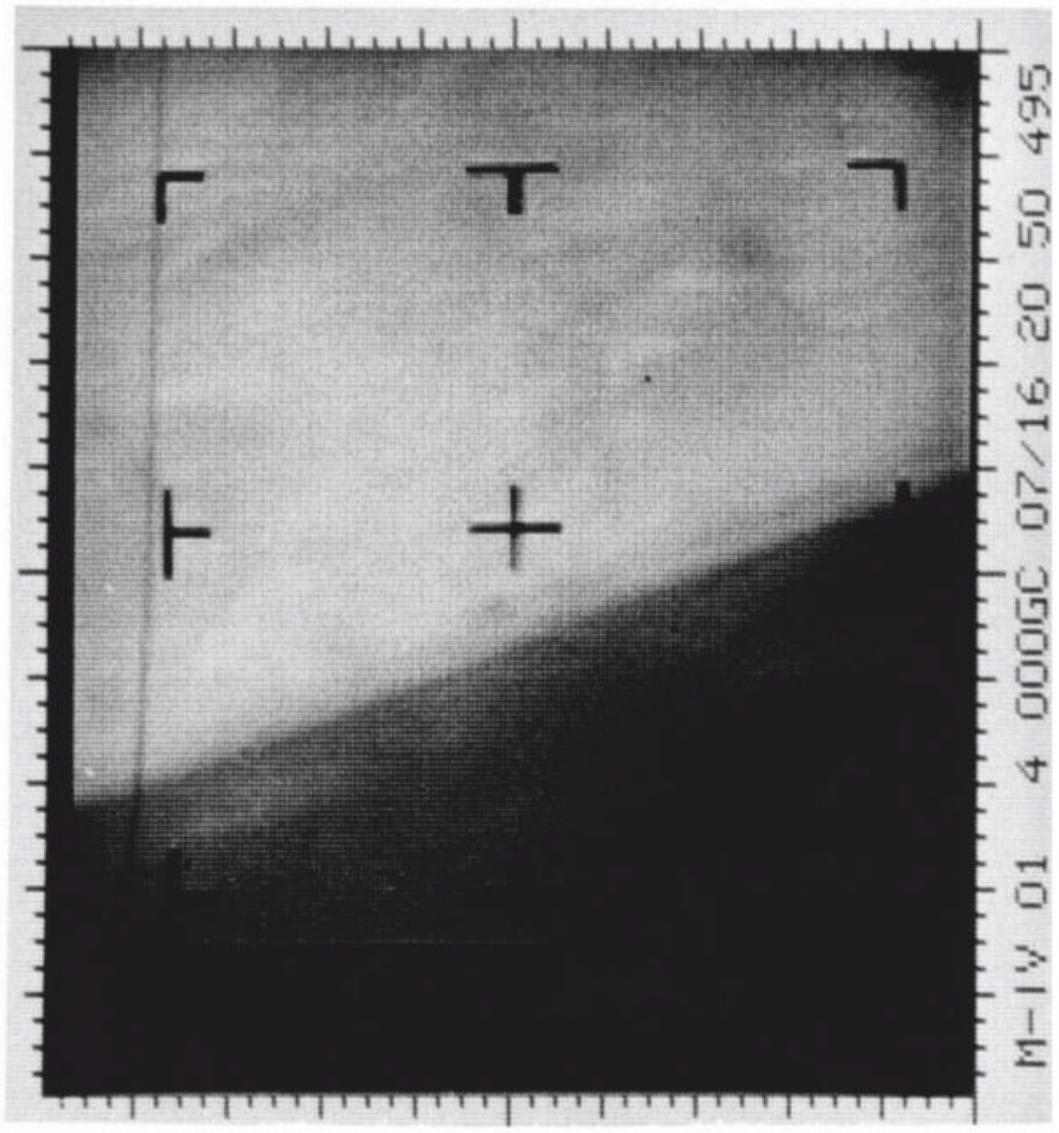
All three missions are scheduled to launch this July and will take about seven months to reach Mars. The simultaneous timing is no coincidence: every 26 months, Earth and Mars are in the right relative positions to enable a fuel-efficient transfer. During the last launch window, in May 2018, NASA sent its InSight lander; this time, an armada of three missions from three different countries will set sail to our planetary neighbour. ►

NASA/JPL-CALTECH, MBRSC (MOHAMMED BIN RASHID SPACE CENTRE), PETMAL/ISTOCK/GETTY IMAGES, CNSA

▸ If it weren't for technical problems and logistical hiccups as a result ofthe COVID-19 pandemic, Europe and Russia's Rosalind Franklin mission would be joining them. Instead, ESA is now targeting the September 2022 launch window. At the time of writing, Perseverance, Tianwen-1 and Hope are still on schedule, despite COVID-19-related travel restrictions and the need for additional quarantine measures. At NASA's Jet Propulsion Laboratory (JPL), for instance, technicians have been working around the clock for the past couple of months to get everything ready on time.

Next steps

Flying past another planet is relatively easy – 55 years ago, Mariner 4 passed by Mars, becoming the first spacecraft to achieve that goal. Entering orbit is harder, with Mariner 9 being the first to succeed, in 1971. The real challenge, though, is a soft landing on the surface, as numerous crashes and failures in the past testify to. So it shouldn't come as a surprise that the United Arab Emirates (UAE) Space Agency isn't aiming for a landing on its first interplanetary space mission, which will arrive at Mars in 2021, the year that the UAE celebrates the 50th anniversary of its foundation.

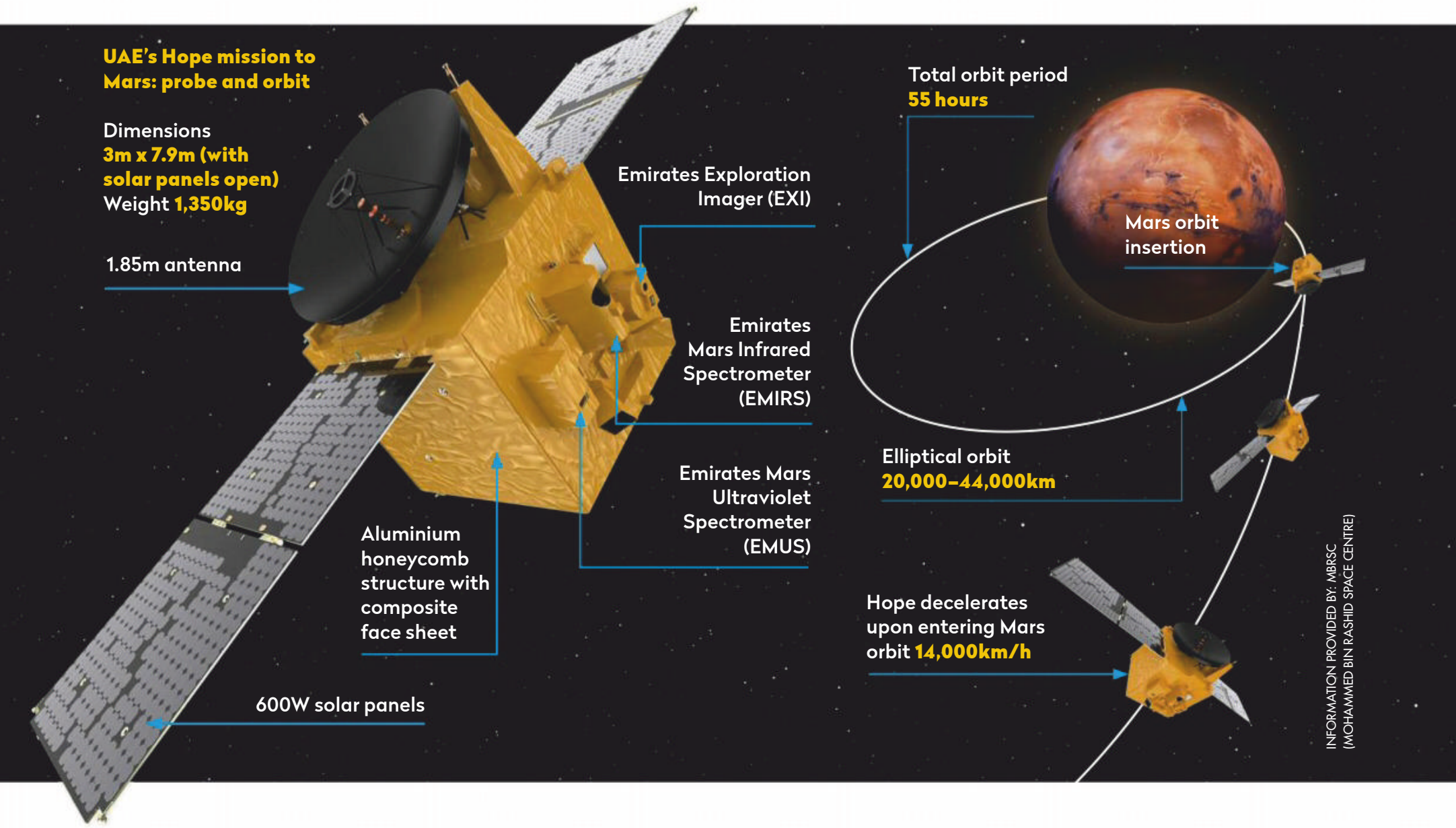


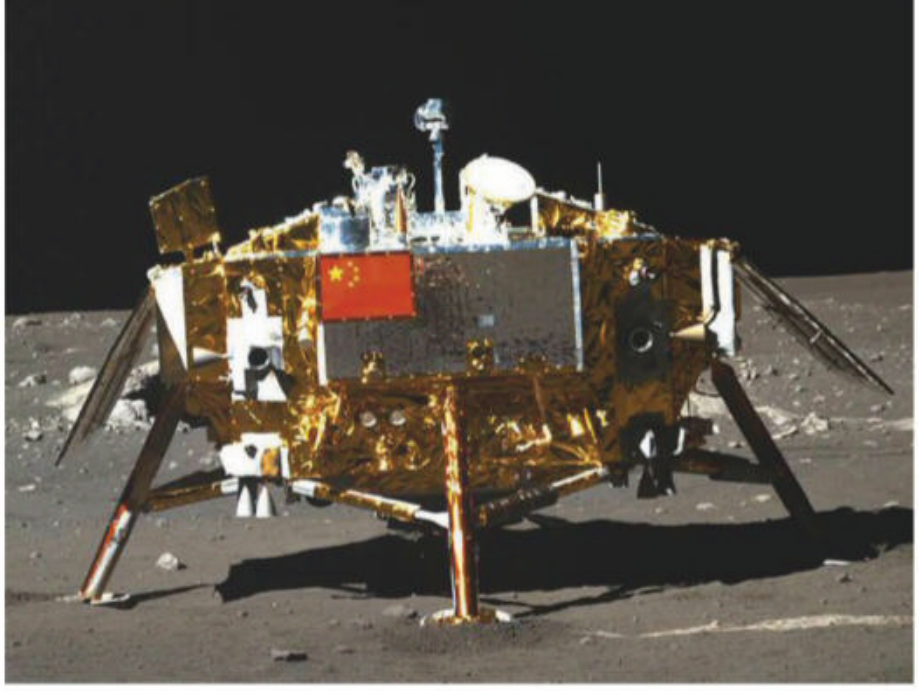
▲ Making history: the first image of Mars was taken by NASA's Mariner 4 on 15 July 1965

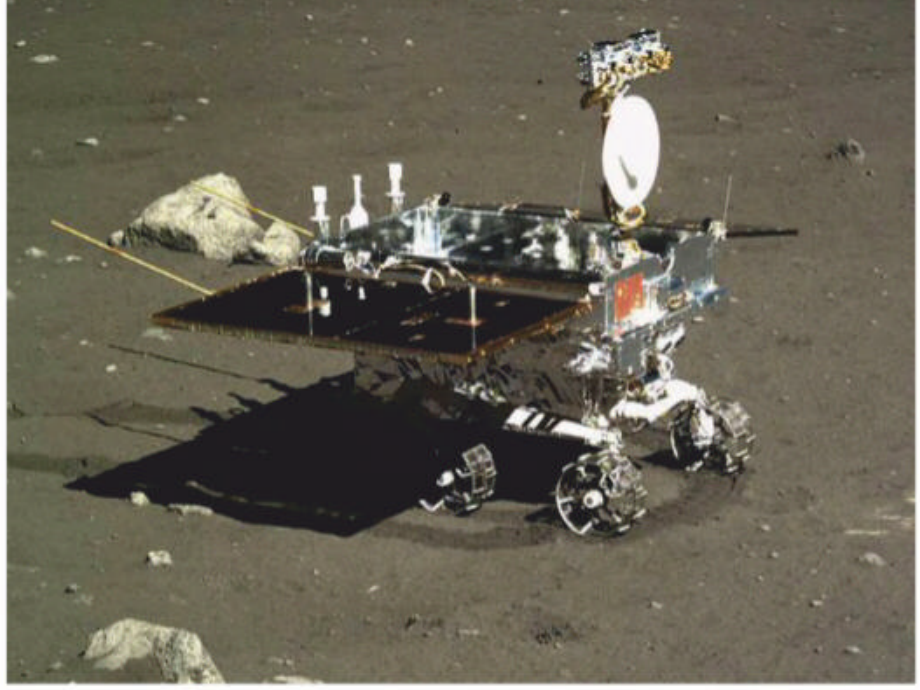
Hope (or 'Al-Amal' in Arabic) is a 1,350kg spacecraft, the size of a small garden shed, built by the Mohammed bin Rashid Space Centre (MBRSC), with important contributions from three American universities. In fact, assembly of the craft took place at the University of Colorado in Boulder. Of the three new Mars missions, Hope may be the first one to leave Earth: the window for its launch on a Japanese H-IIA rocket opens on 14 July.

From its wide, 55-hour elliptical orbit, with the lowest point still at 20,000km from the planet's surface, Hope will operate as a Martian global

▼ Taking the lead: the UAE's Hope mission is likely to launch first







NASA/JPL-CALTECH/DAN GOODS, MBRSC (MOHAMMED BIN RASHID SPACE CENTRE), XINHUA/ALAMY STOCK PHOTO X 2, ESA/ATG MEDIALAB, NASA/JPL-CALTECH

weather satellite, using a camera as well as infrared and ultraviolet spectrometers to study wind patterns, dust storms, daily and seasonal weather changes and atmospheric processes that may shed light on long-term climate evolution.

▲ Past inspirations: technology for China's Tianwen-1 mission craft will be drawn from the Chang'e lunar lander and rover (above, left and right)

Spirit of collaboration

Compared to Hope, China's Tianwen-1 mission (the name translates as 'heavenly questions') is much more ambitious, although the China Aerospace Science and Technology Corporation (CASC) hasn't revealed many details about the project. "We do not know much about the Chinese mission," says Jorge Vago, the European project scientist for the Rosalind Franklin mission, "although we have some collaboration, providing them with data from our Mars Express orbiter on their selected landing location." In September 2019, China chose two potential landing sites in Utopia Planitia, the huge rolling northern hemisphere plain where NASA's Viking 2 lander touched down back in 1976.

Tianwen-1 is a three-part space mission, consisting of an orbiter, a lander and a small rover. After launch on a Long March 5 rocket, the five-tonne spacecraft will enter Mars orbit in February next year, but the lander probably won't descend until April or May 2021. Both the lander and the 240kg rover are based on the design of China's successful Chang'e lunar missions. The orbiter and the rover carry a suite of cameras and scientific instruments to study surface composition and magnetic fields. Scientists are particularly interested in the rover's ground-penetrating radar instrument, which will map subsurface layers down to a depth of 100m.

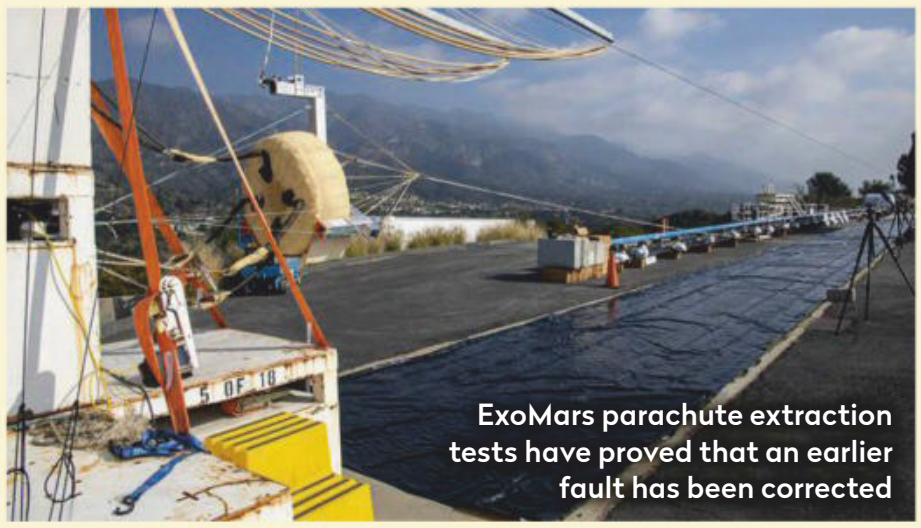
By far the most versatile mission in the new Mars armada, however, is NASA's plutonium-powered, one-tonne Perseverance rover. Building on the experience ►

Rosalind Franklin

Not all missions hoping to reach Mars managed to meet the summer deadline

ILLUSTRATION

Rosalind Franklin is now scheduled for launch in September 2022



ExoMars parachute extraction tests have proved that an earlier fault has been corrected

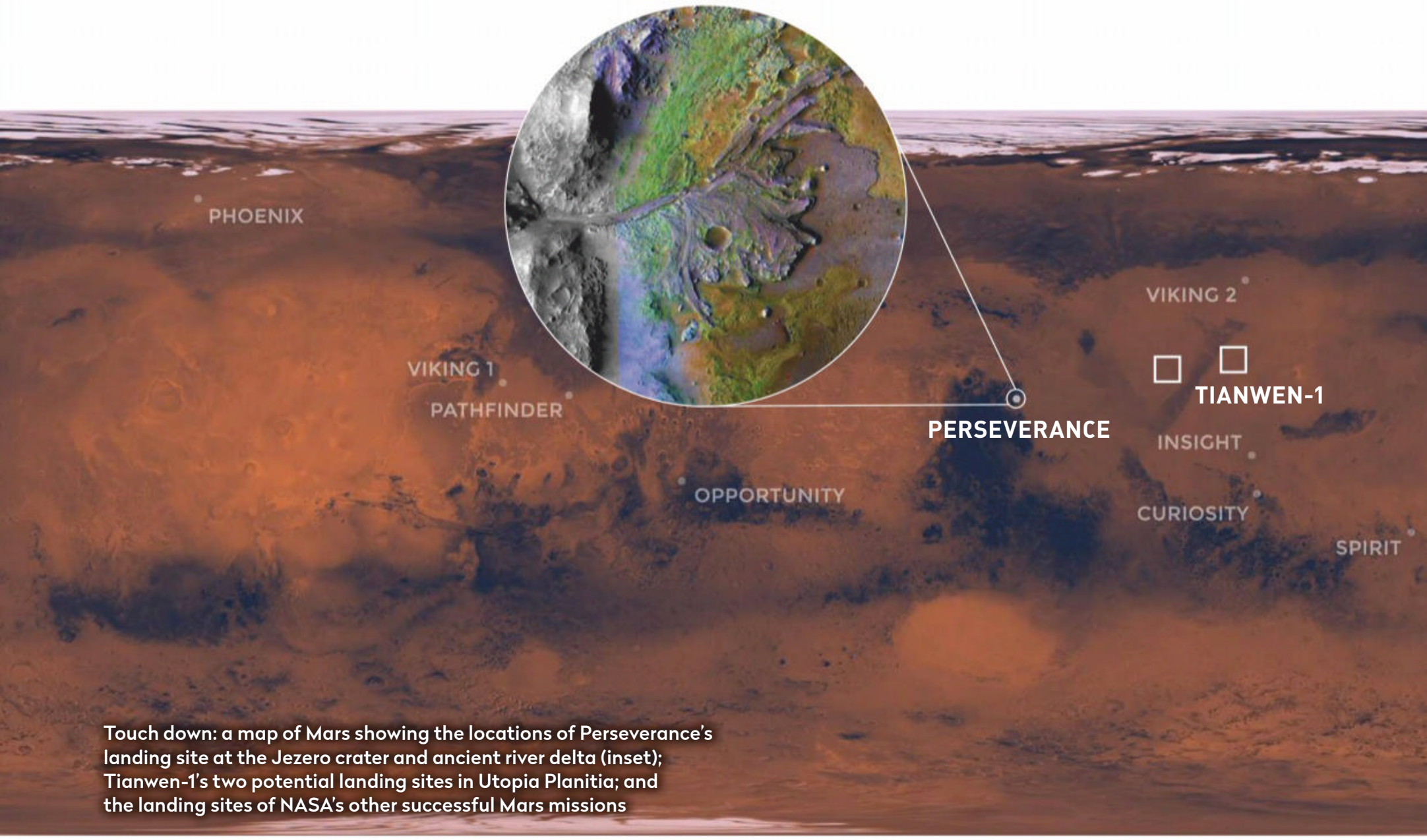
The European Space Agency's (ESA's) Rosalind Franklin rover has been beset with problems, predominantly with its giant parachutes. While these issues have now been solved, says project scientist Jorge Vago, they couldn't be executed in time for the launch – partly due to travel restrictions imposed by COVID-19. "As it is, the earliest we will be able to execute these tests is late September 2020," says Vago.

Rosalind Franklin – named after the British co-discoverer of DNA – is part of ESA's ExoMars programme. Russia is providing the Kazachok lander that will deploy the rover to the surface and the Proton-M rocket which will launch it in September 2022, aiming for an arrival in spring 2023.

According to Vago, the project's delay provides an opportunity to carry out a few improvements to the rover, such as replacing one of the spectrometers with a better-performing spare, upgrading software and electronics, and reinforcing the hinges of the solar arrays.

Once on Mars, Rosalind Franklin will use its 2m-drill to go beneath the Martian surface and search for biosignatures of past Martian life. Alongside this are cameras, microscopes, spectrometers and an organic molecule analyser. The rover will work alongside the first instalment of the ExoMars programme, the Trace Gas Orbiter (TGO), which has been at the Red Planet since 2016, to gain a complete picture of what Mars is like.

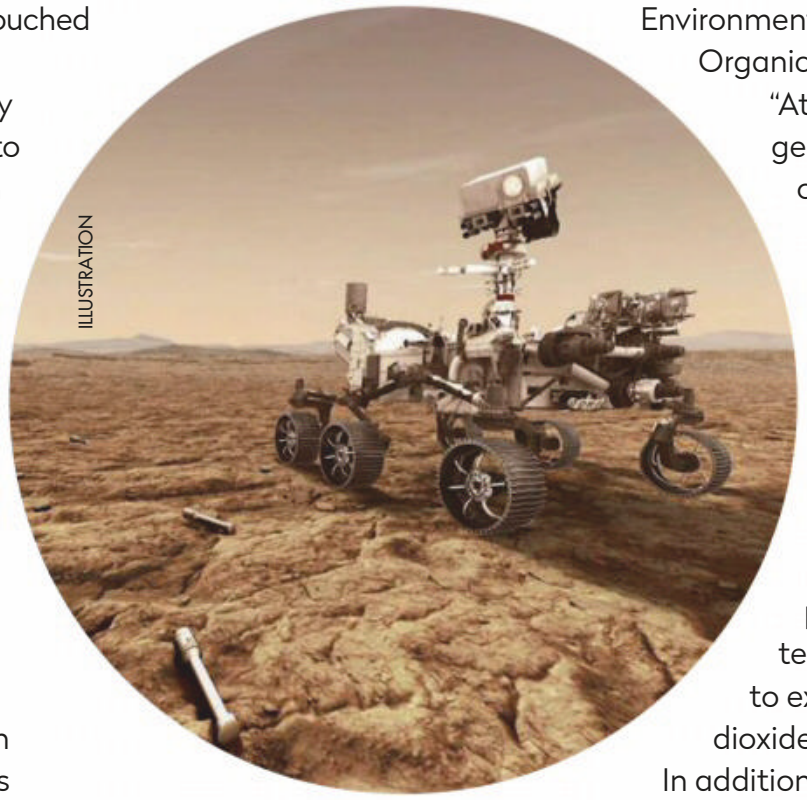
"The good new is that TGO is doing great," says Vago, "And we have fuel for more than 20 years."



Touch down: a map of Mars showing the locations of Perseverance's landing site at the Jezero crater and ancient river delta (inset); Tianwen-1's two potential landing sites in Utopia Planitia; and the landing sites of NASA's other successful Mars missions

► (and the design) of Curiosity, which touched down on Mars almost eight years ago, Perseverance's main mission is to study the habitability of the Red Planet and to seek signs of ancient life in the Martian rock record, according to deputy project scientist Katie Stack Morgan at the Jet Propulsion Laboratory. "I am optimistic that life could once have existed on Mars," she says, "and Perseverance is well-equipped to search for – and hopefully find – potential biosignatures."

Perseverance will launch on an Atlas V rocket from Cape Canaveral, with the window of opportunity beginning on 17 July. Like Curiosity, it will immediately dive into the Martian atmosphere, using novel autonomous technologies to make sure it lands precisely at the desired location. That spot is in the western part of the 50km-crater Jezero, close to a huge, fan-shaped ancient river delta. Scientists believe that Jezero once contained a lake, so it's an ideal place to look for fossil evidence of microbial life.



▲ Perseverance will store rock and soil samples in sealed tubes on the Martian surface for future missions to retrieve

Breakthrough discoveries

One of the main objectives of Perseverance is to take soil samples and to prepare them for future return to Earth but according to Stack Morgan, the rover's own instruments also have the potential to make breakthrough discoveries. This is especially true for PIXL (Planetary Instrument for X-ray Lithochemistry) and SHERLOC (Scanning Habitable Environments with Raman and Luminescence for Organics and Chemicals).

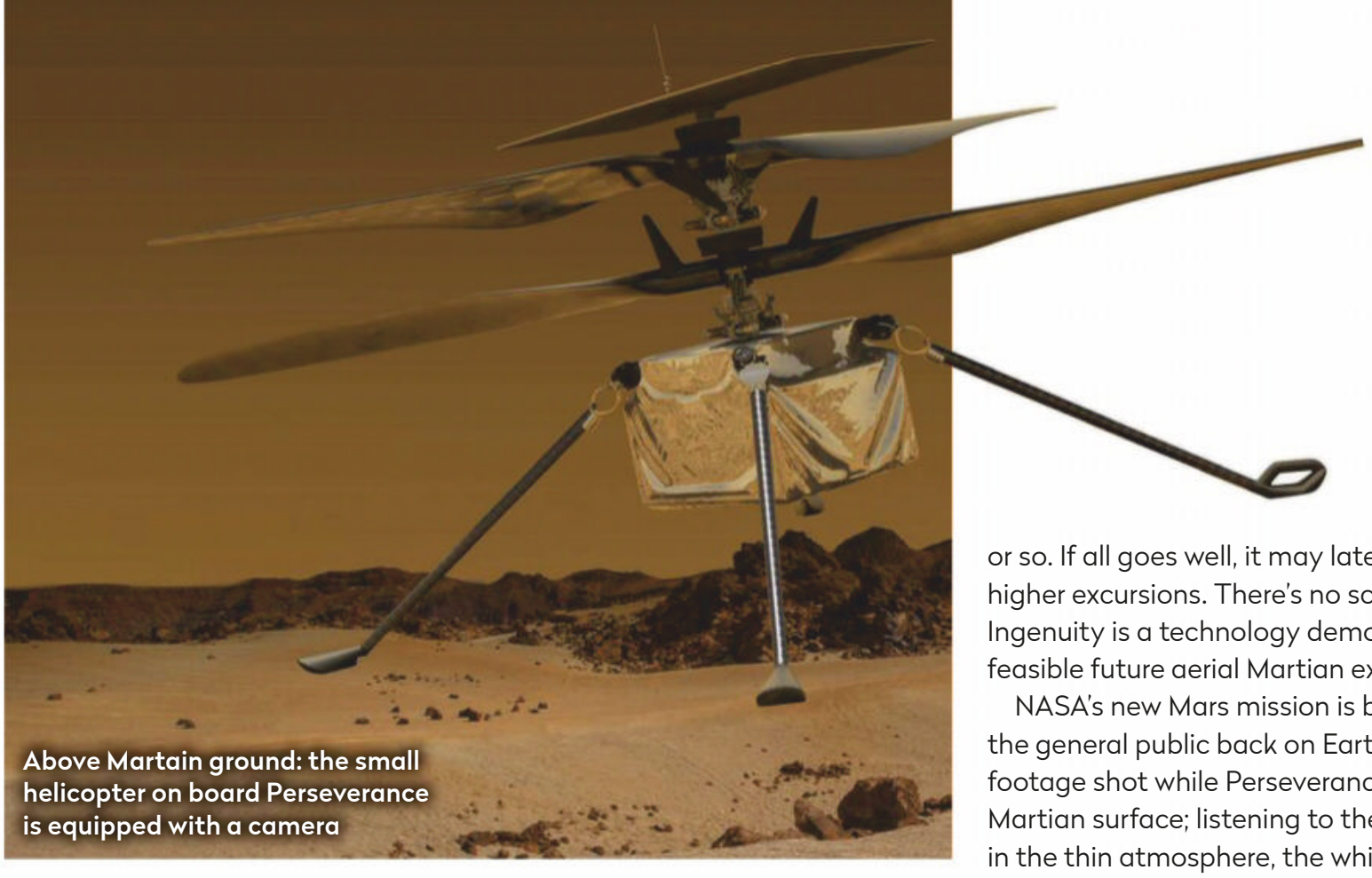
"At a very fine scale, they will map the geochemistry, mineralogy, distribution of organics, and compelling texture within the rocks," she says. "These are the same strategies we use on Earth to search for signs of life in our own rock record."

Apart from PIXL and SHERLOC, which are located on the rover's robotic arm, Perseverance's instruments include a weather station (MEDA), a ground-penetrating radar (RIMFAX), and a technology demonstrator experiment to extract oxygen from the thin, carbon dioxide-rich Martian atmosphere (MOXIE).

In addition, the rover carries no less than 23 cameras. Most of these are relatively simple, black-and-white navigation and hazard avoidance cameras, but two cameras stand out. SuperCam fires a laser at a distant target and uses spectrometers to study the resulting vapour, thus identifying the rock's atomic and molecular make-up. Meanwhile, Mastcam-Z will routinely acquire 3D colour images of the surrounding landscape at various zoom settings.

"Mastcam-Z can see features as small as a house fly, all the way from a distance that's about the length of a soccer field," says Mastcam-Z principal investigator Jim Bell, who is based at Arizona State University. The high-resolution stereo views provided by the twin cameras will be used to assess potential paths for the rover to traverse, and to create digital

NASA/JPL-CALTECH X 4, NASA/JPL-CALTECH/ASU



Above Martain ground: the small helicopter on board Perseverance is equipped with a camera

ILLUSTRATION

terrain models for scientific uses, he adds. Both SuperCam and Mastcam-Z are mounted on the rover's 2m-tall mast. Incidentally, Mastcam-Z will also be able to shoot high-definition video. Moreover, the rover carries two microphones – a first on any Mars mission.

Even more exciting is the small, 2kg-helicopter on board Perseverance. Called Ingenuity, the twin-rotor, drone-like device is powered by solar cells and is equipped with a small camera. Over a period of 30 days, engineers plan to carry out 90-second test flights in the thin Martian air, up to an altitude of 5m or so. If all goes well, it may later attempt longer and higher excursions. There's no science involved here; Ingenuity is a technology demonstrator to see how feasible future aerial Martian explorers might be.

NASA's new Mars mission is bound to inspire the general public back on Earth. Imagine seeing footage shot while Perseverance drives across the Martian surface; listening to the sound of the wind in the thin atmosphere, the whirring of the rover's instruments, and the 'pop-pop-pop' sounds of its SuperCam laser while an ingenious onlooker watches from above.

Planetary scientists, geologists and astrobiologists alike look forward to the wealth of new data that awaits them, not just from Perseverance, but also from Hope and Tianwen-1. The 2020 Mars armada constitutes an important extension to the current fleet of operational orbiters, landers and rovers, and there's even more to come in the future. As Bell says: "The challenge is to solve the Red Planet's mysteries and to help the future spacecraft, and – eventually – people that will be heading out to Mars."

Govert Schilling is is an astronomy journalist and broadcaster, and author of *Ripples in Spacetime*

Mars sample return

Perseverance is just the first stage in an ambitious plan

NASA intends to launch a Mars Ascent Vehicle with the collected samples from the surface of Mars

ILLUSTRATION

One of the most important tasks of NASA's Perseverance rover is to collect soil samples and prepare them for a future return to Earth, where geologists and astrobiologist can study them in fully equipped terrestrial laboratories. "It's thrilling to think that these samples have the potential to lead to major, possible paradigm-shifting discoveries about Mars, our Solar System, and life beyond Earth," says deputy project scientist Katie Mack.

Perseverance will seal the precious material – pebbles, soil and atmosphere – in some 40 titanium capsules that will be left at a small number of recovery spots, to be collected by a future space mission – probably a NASA/ESA collaborative effort. This new, as-yet undefined (and un-funded) mission will comprise an orbiter, a lander, a small rover, some sort of capsule launch mechanism, the retrieval of the capsules in Mars orbit, a return flight to Earth, and a parachute drop of the container carrying the samples.

Given the necessary time to develop this complex mission, and the infrequent launch windows for a flight to Mars, it's unlikely that scientists will have 'fresh' samples from the Red Planet under their microscopes before the early 2030s. Mastcam-Z's principal investigator Jim Bell, says: "For me, the idea of being able to help identify and select these samples is super exciting."

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BBC Sky at Night MAGAZINE

16-PAGE STARGAZING GUIDE

The Sky Guide

AUGUST 2020

PEAK OF THE PERSEIDS

Observe a prolific summer meteor shower that rarely disappoints

IN GANYMEDE'S SHADOW

When to watch the transit of Jupiter's largest moon

THIN SIDE OF THE MOON

Spot the wafer thin lunar crescent as new Moon approaches

PETE LAWRENCE

About the writers

Astronomy expert **Pete Lawrence** is a skilled astro imager and a presenter on *The Sky at Night* on BBC Four

Steve Tonkin is a binocular observer. Find his tour of the best sights for both eyes on page 50

Also on view this month...

- ✦ Venus reaches greatest western elongation
- ✦ Get to know the lunar crater Archimedes
- ✦ Can you estimate the brightness of Delta Cephei?

Red light friendly

To preserve your night vision, this Sky Guide can be read using a red light under dark skies

Get the Sky Guide weekly

For weekly updates on what to look out for in the night sky and more, sign up to our newsletter at **www.skyatnightmagazine.com**

AUGUST HIGHLIGHTS

Your guide to the night sky this month

Early August

The 2020 season of noctilucent clouds (NLCs) is drawing to a close, with the start of August being the last chance to spot these elusive night shining sights. Look low above the northwest horizon, 90–120 minutes after sunset, or at a similar time before sunrise.

Saturday 1

Look for Jupiter this evening 1.5° to the north of an almost full Moon. The gas giant appears 2.5° from the centre of the lunar disc at 23:00 BST (22:00 UT).

Meanwhile, mag. +0.5 Saturn lies a little less than 8° to Jupiter's east.

Monday 3

Mars is at perihelion, a time when it's closest to the Sun. Perihelion season raises the chance of dust storms on the Red Planet.

Tuesday 4

As a bright Moon, just past full, rises above the east-southeast horizon at 22:00 BST (21:00 UT) tonight, look out for the Moon illusion, when it appears artificially large.

Sunday 9

Brightening Mars lies 3.5° from the 73%-lit waning gibbous Moon at 03:00 BST (02:00 UT). The Red Planet is shining at mag. –1.2. By 10:30 BST (09:30 UT) both objects will be 1.1° apart in the daytime sky.

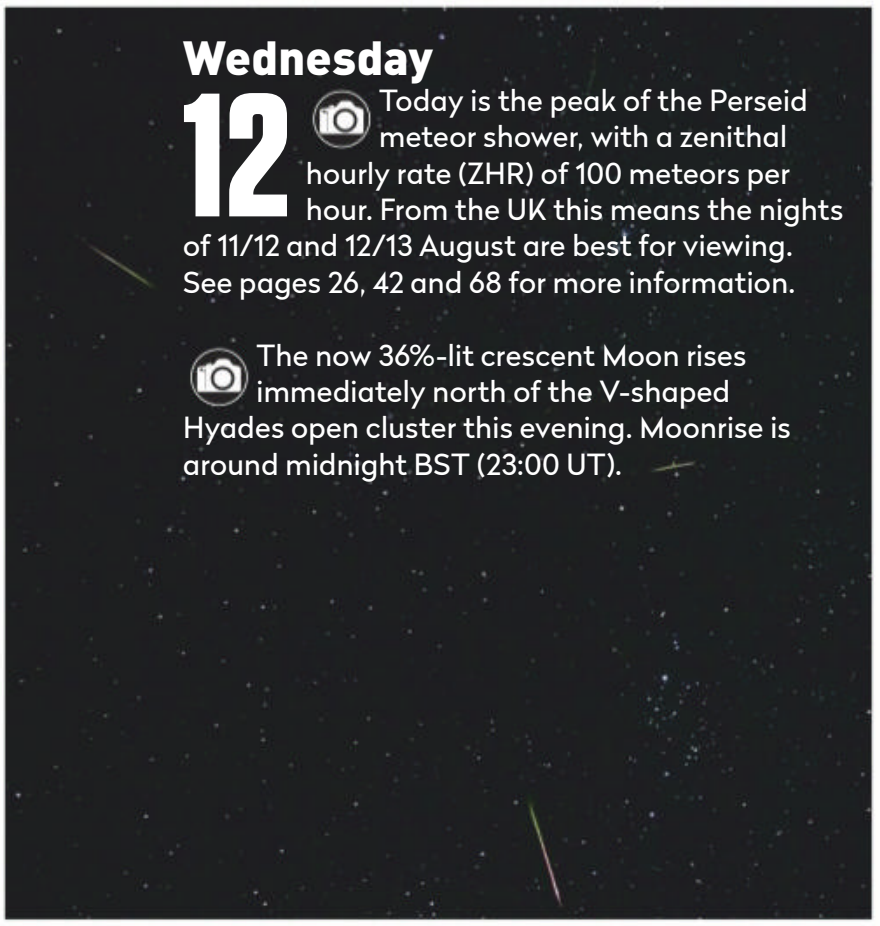
Tuesday 11

The shadow of the moon Callisto transits Jupiter's disc from 19:43 BST (18:43 UT) until 23:55 BST (22:55 UT), with the shadow located centrally on the gas giant's disc at 21:35 BST (20:35 UT).

Wednesday 12

Today is the peak of the Perseid meteor shower, with a zenithal hourly rate (ZHR) of 100 meteors per hour. From the UK this means the nights of 11/12 and 12/13 August are best for viewing. See pages 26, 42 and 68 for more information.

The now 36%-lit crescent Moon rises immediately north of the V-shaped Hyades open cluster this evening. Moonrise is around midnight BST (23:00 UT).



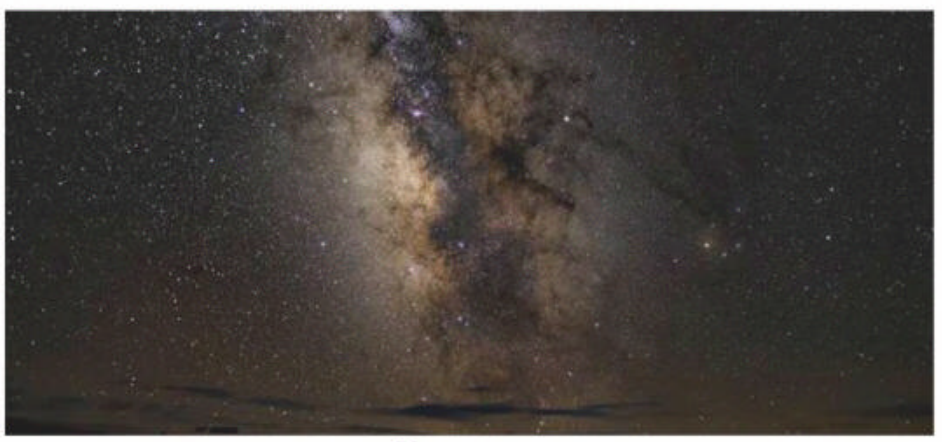
◀ Saturday 15

This morning's 18%-lit waning crescent Moon lies 1.3° south of the fifth magnitude open cluster, M35.

Mag. –4.2 Venus sits 6° east-southeast of the Moon at 03:00 BST (02:00 UT).

Wednesday 19

Today's new Moon means this is a good time to try our 'Deep-Sky Tour' on page 52. This month we're looking at objects in western Cygnus.



◀ Thursday 20

With the Moon out of the way the Milky Way should be visible tonight, providing the sky is clear of cloud and you're in a dark-sky location.

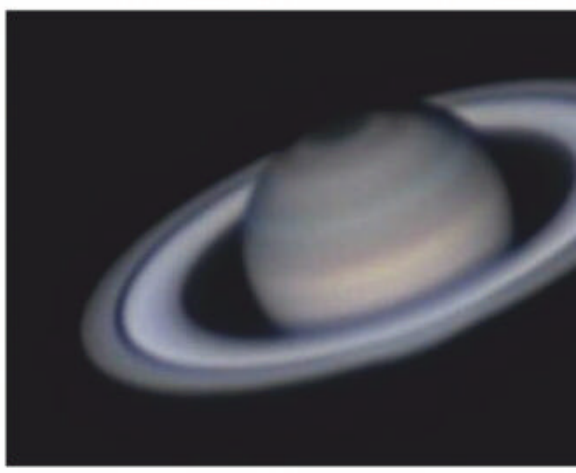
Family stargazing

The peak of the Perseid meteor shower occurs on the nights of the 11/12 and 12/13 August, with the best time to watch being in the early hours, from 01:00 BST (midnight UT) to the onset of dawn around 03:30 BST (02:30 UT). It might sound late for younger kids, but it could make an exciting summer adventure. Encourage an early sleep before the morning watch and make things comfortable; with no lights, a sleeping bag and a hot drink. All that's required is to look up and wait. If you see a meteor trail, it's something your kids won't forget for a long time. See page 42 for more details. **www.bbc.co.uk/cbeebies/shows/stargazing**

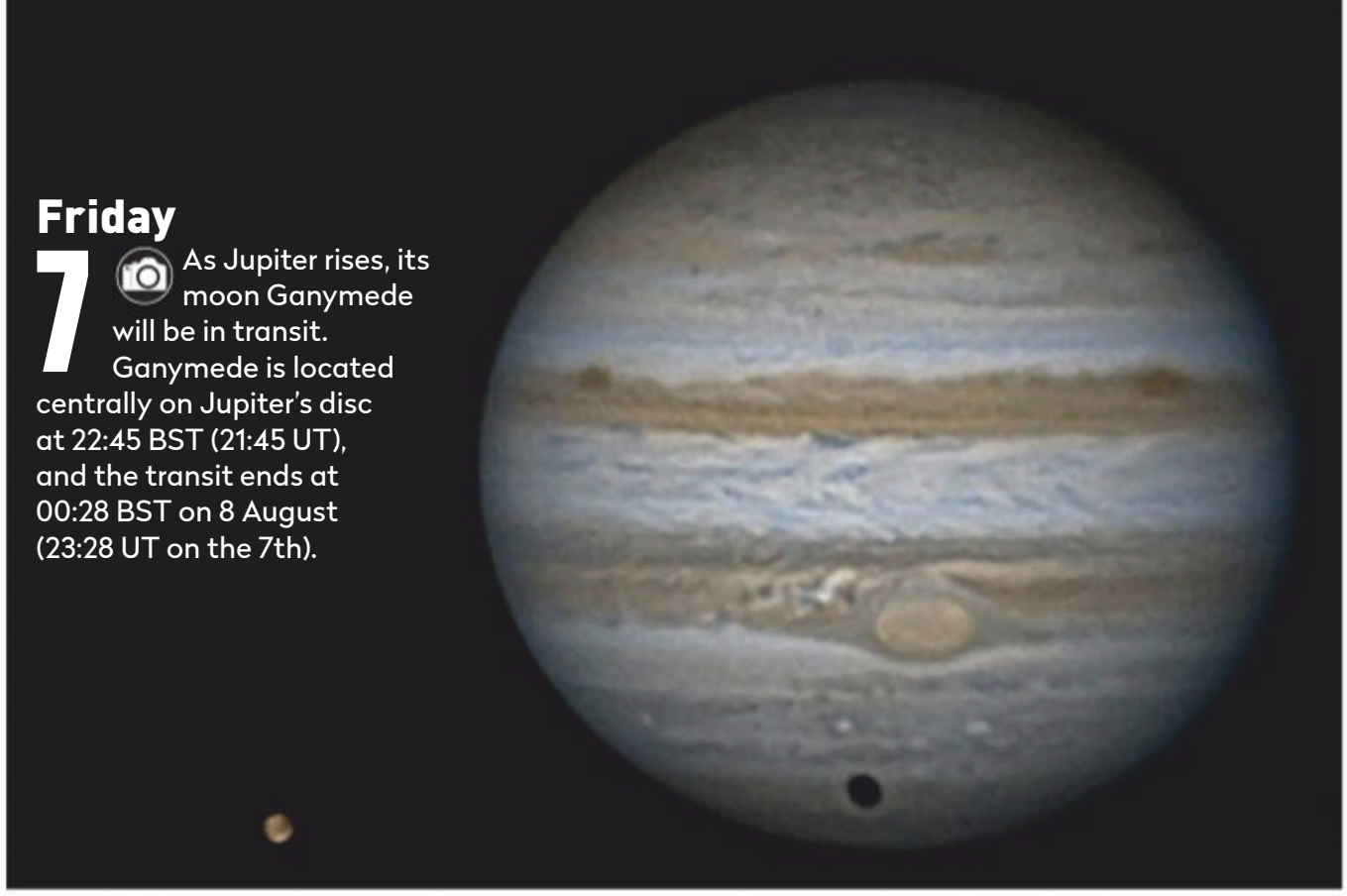
Friday 28

This evening an 81%-lit waxing gibbous Moon lies 3.7° southwest of mag. –2.4 Jupiter.

Minor planet 1 Ceres reaches opposition in Aquarius at mag. +7.7 this evening.



PETE LAWRENCE X 7

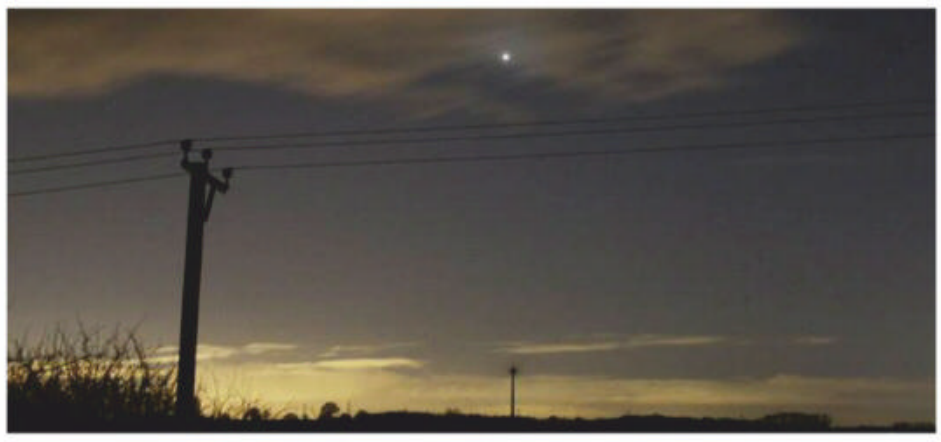


Friday 7

As Jupiter rises, its moon Ganymede will be in transit. Ganymede is located centrally on Jupiter's disc at 22:45 BST (21:45 UT), and the transit ends at 00:28 BST on 8 August (23:28 UT on the 7th).

Thursday ▶ 13

Venus reaches greatest western elongation today, appearing separated from the Sun by 45.8° in the morning sky. Venus is now theoretically at 50 per cent phase. See page 43 for more.



Monday 17

Mars brightens to mag. –1.5 today. Catch it around midnight low in the east, where it looks like a glowing orange ember nestled among the faint stars of Pisces.

Wednesday 26

This evening's low 62%-lit waxing gibbous Moon is a great time to observe our 'Moonwatch' target, beautiful crater Archimedes, just visible close to the northern section of the terminator. See page 48.

◀ Saturday 29

As the sky darkens, mag. +0.6 Saturn appears 4° northwest of a bright 88%-lit waxing gibbous Moon.

Tuesday 18

There's an opportunity to spot a 1%-lit waning crescent Moon this morning, as it rises above the east-northeast horizon at 04:30 BST (03:30 UT), 90 minutes before sunrise.

Look out for the peak of the weak Kappa Cygnid meteor shower, with a zenithal hourly rate (ZHR) of 2.3 meteors per hour.

NEED TO KNOW

The terms and symbols used in *The Sky Guide*

Universal time (UT) and British Summer Time (BST)
Universal Time (UT) is the standard time used by astronomers around the world. British Summer Time (BST) is one hour ahead of UT

RA (Right ascension) and dec. (declination)
These coordinates are the night sky's equivalent of longitude and latitude, describing where an object is on the celestial 'globe'

Family friendly
Objects marked with this icon are perfect for showing to children

Naked eye
Allow 20 minutes for your eyes to become dark-adapted

Photo opp
Use a CCD, planetary camera or standard DSLR

Binoculars
10x50 recommended

Small/ medium scope
Reflector/SCT under 6 inches, refractor under 4 inches

Large scope
Reflector/SCT over 6 inches, refractor over 4 inches

GETTING STARTED IN ASTRONOMY

If you're new to astronomy, you'll find two essential reads on our website. Visit **http://bit.ly/10_easylessons** for our 10-step guide to getting started and **http://bit.ly/buy_scope** for advice on choosing a scope

THE BIG THREE

The three top sights to observe or image this month

DON'T MISS

2020 PERSEIDS

BEST TIME TO SEE: 1–23 August, peak on the night of 12/13 August

August is the month when the Perseid meteor shower reaches peak activity. Fortunately, it's one of the most prolific showers in the annual calendar and a fairly reliable performer. The enemy of meteor showers is moonlight and this year, although present, the Moon should be reasonably manageable.

The Perseid peak for 2020 is expected to occur between 14:00 BST (13:00 UT) and 17:00 BST (16:00 UT) on 12 August which is, of course, during daylight hours. This means the best opportunities for spotting Perseid meteors will be on the nights of 11/12 August and 12/13 August.

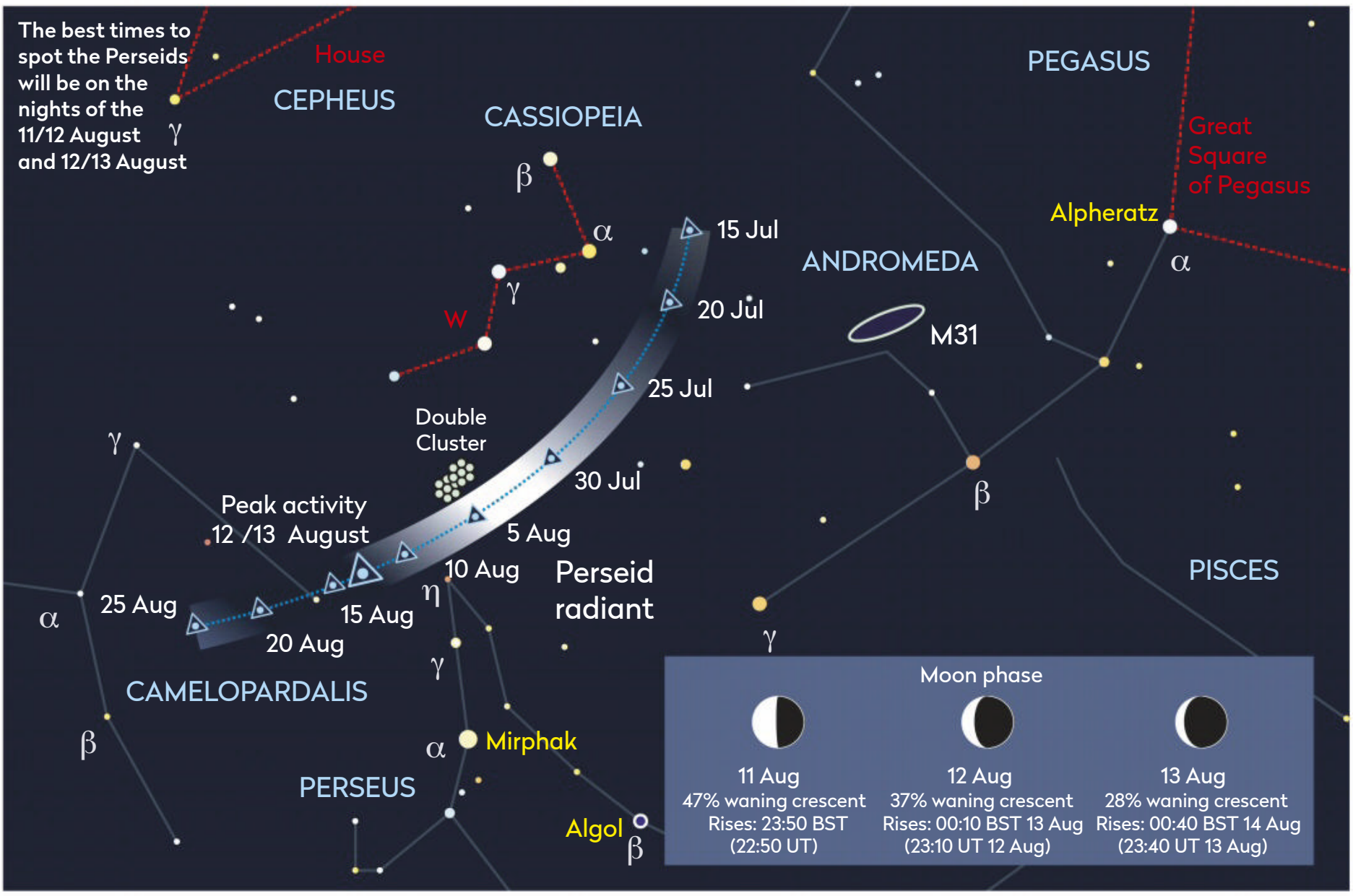
On the night of 11/12 August the Moon will be just after its last quarter phase, 47%-lit. It rises at 23:50 BST (22:50 UT), reaching a height of 30° at the end of astronomical darkness. The following night, the now 37%-lit crescent Moon rises at 00:10 BST on 13 August (23:10 UT on 12 August) and reaches a height of 27° as darkness ends.

The best strategy for dealing with the Moon will be to simply block it out. Although it will cast some light across the sky, at half phase or less, this will be significantly reduced compared to a bright gibbous Moon. A building or fence that blocks its light should be sufficient to retain reasonable darkness.

Perseid rates typically climb and fall quite steeply in the hours running up to and from the peak itself. In addition, the orientation of Earth with respect to its motion around the Sun changes through the course of a 24-hour period. Your local position is best placed in the hours after local midnight, when your part of Earth has effectively turned to face incoming meteoroids head on. This raises impact energy, resulting in more and brighter trails. As the predicted peak period is fairly evenly positioned between the morning periods of 12 and 13 August, observing on 11/12 August should provide a decent build up to the peak. Although the evening of 12/13 August should still show the run down from the peak, Earth's orientation pre-midnight UT will dampen this a little.

The shower is produced when Earth passes through dust debris strewn around the orbit of comet 109P/Swift-Tuttle. While a typical peak Perseid display produces a zenithal hourly rate (ZHR) of around 110 meteors per hour, bright events are common and brighter trails are often accompanied by a weakly glowing column of ionised gas known as a meteor train.

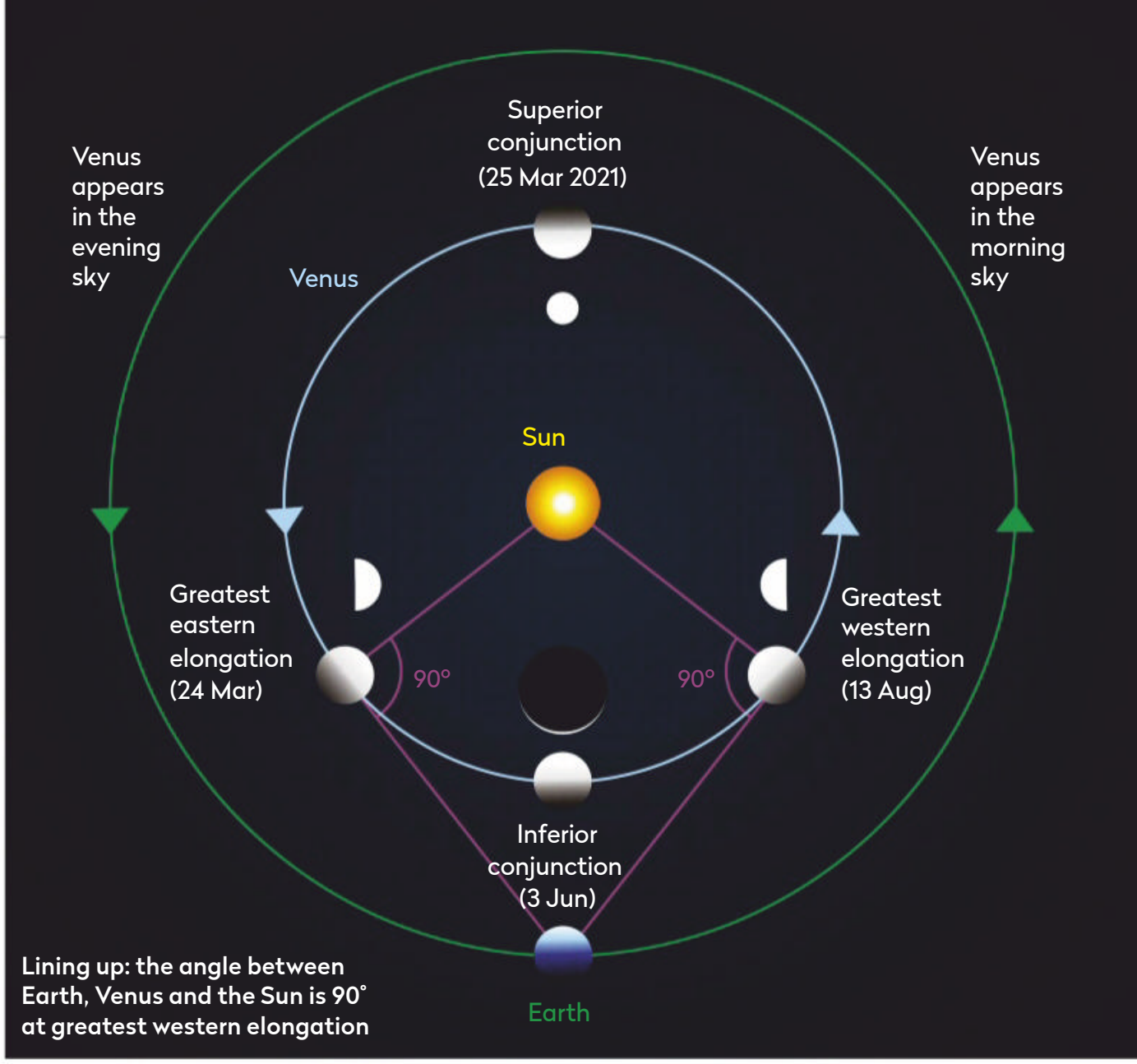
Perseid activity can typically occur between 17 July and 24 August, but outside the peak dates rates will be low. A number of weaker showers overlap the Perseids, providing quite a spectacle for August stargazers.



ALL PICTURES: PETE LAWRENCE

Venus reaches greatest western elongation

BEST TIME TO SEE: All month, elongation on 13 August



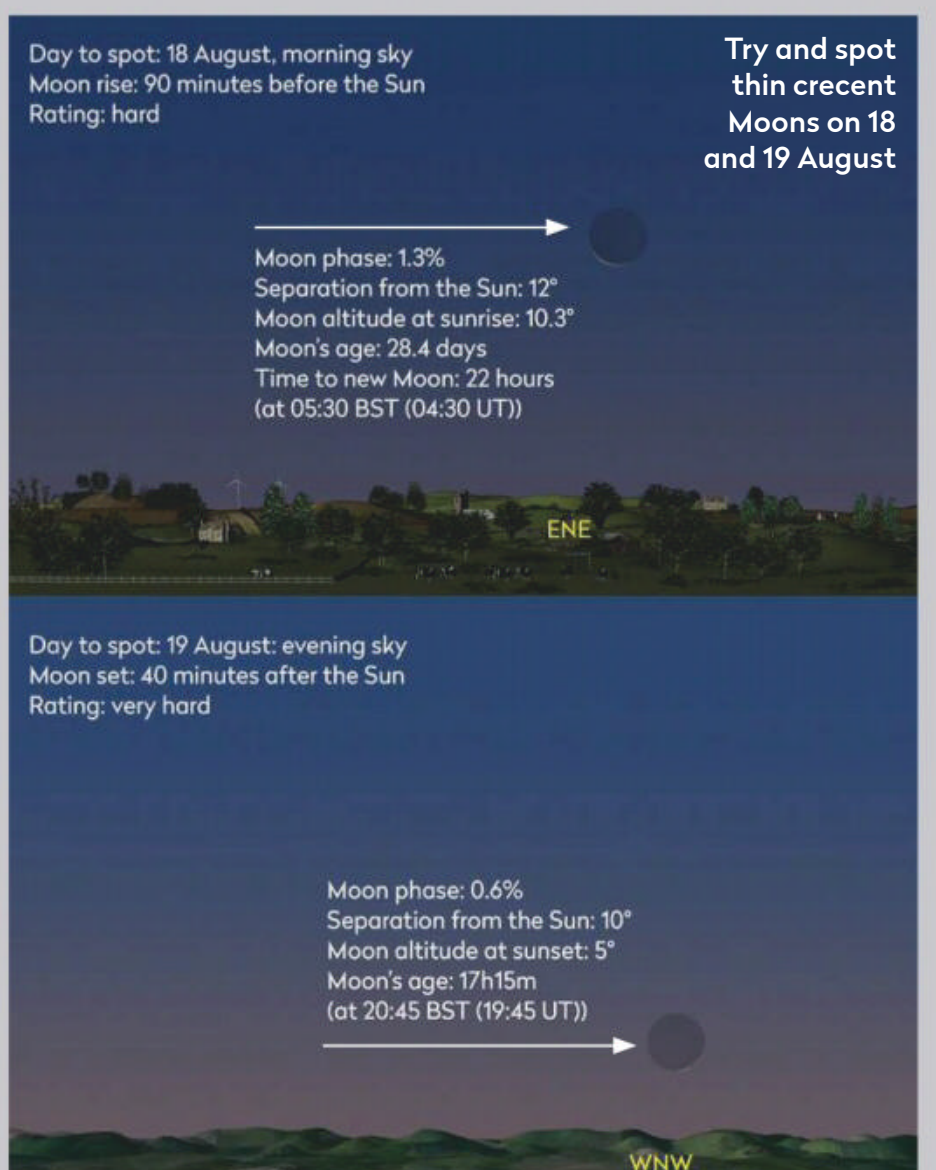
Lining up: the angle between Earth, Venus and the Sun is 90° at greatest western elongation

Venus was the beacon of the evening twilight sky during the first half of 2020, but rapidly left the scene during May as it approached inferior conjunction on 3 June. After this it reappeared in the morning sky, moving quickly away from the Sun as it traversed the part of its orbit close to Earth.

This month Venus reaches a point in its orbit known as greatest western elongation, a position where the angle between Earth, Venus and the Sun is 90°, and the planet appears to be at its furthest west of the Sun. As a result, on 13 August it will appear separated from the rising Sun by 46°. In addition, the geometry of the situation means that Venus should appear to exhibit a 50%-lit phase at this time, but this is often not the case due to what's known as the Schröter Effect. Believed to be due to the atmospheric scattering of light in Venus's thick atmosphere, the Schröter Effect causes the 50%-lit phase to occur a few days early when Venus is in the evening sky at greatest eastern elongation, and a few days later than would be predicted by geometry when Venus is at greatest western elongation.

Interestingly, when you use a mid- to high-power telescope it's possible to see the phase slightly offset through different colour filters. For example, through a blue filter the phase often looks slightly less than if you try a yellow or red filter. If you're visually observing the planet, make estimates of the percentage it is lit – how far the terminator extends across the entire disc – and see when you think the point of dichotomy or 50%-illumination occurs.

Venus will remain in the morning sky for the rest of 2020, finally lining up with the Sun once more – on the far side of its orbit – at superior conjunction on 25 March 2021.



Thin Moon spotting

BEST TIME TO SEE: 18 August from 90 minutes before sunrise; 19 August from just after sunset

CAUTION Don't attempt to look unless the Sun is below the horizon

In theory, as the Moon approaches its new phase in the morning sky, the reducing separation from the Sun should mean its illuminated phase gets thinner, reaching minimum at new Moon. Then, its phase should grow incrementally as another lunar cycle begins.

In practice there is a period of invisibility either side of the Sun. Known as the 'Danjon limit', this defines when the lunar crescent should disappear and reappear either side of new Moon. The invisibility zone occurs because the Moon has a rough edge and this curtails the appearance of super thin Moons, limiting visibility to when the Moon is over 7° centre-to-centre from the Sun.

If it's clear on the morning of 18 August, try spotting a thin 1%-lit waning crescent Moon, 11° from the Sun, just 22 hours before new Moon occurs. Note that moonrise occurs 90 minutes before sunrise on this date. For a trickier spot, try the evening crescent on 19 August. This one lies just under 10° from the Sun and sets 40 minutes after sunset.

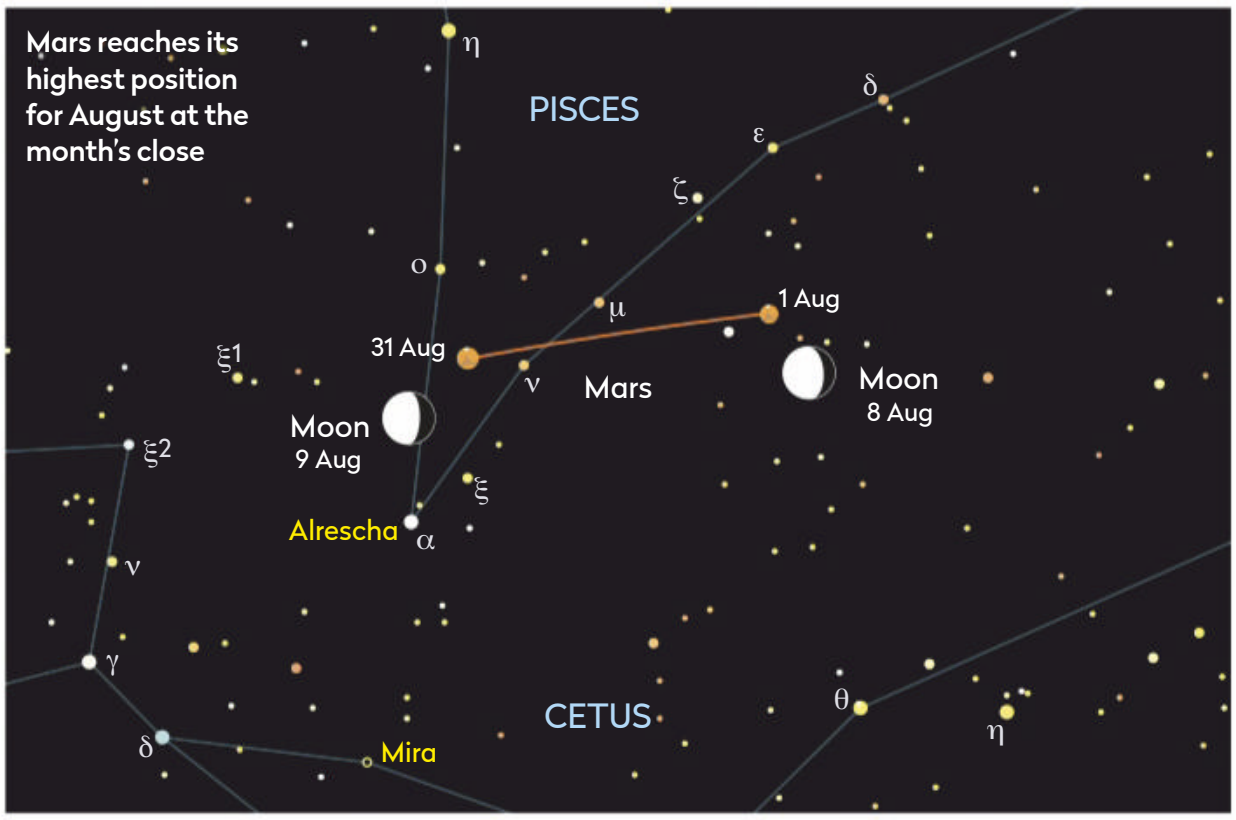
THE PLANETS

Our celestial neighbourhood in August

PICK OF THE MONTH

Mars

Best time to see: 31 August, 04:00 BST (03:00 UT)
Altitude: 43°
Location: Pisces
Direction: South
Features: Dark 'albedo' features, polar caps and weather
Recommended equipment: 150mm or larger

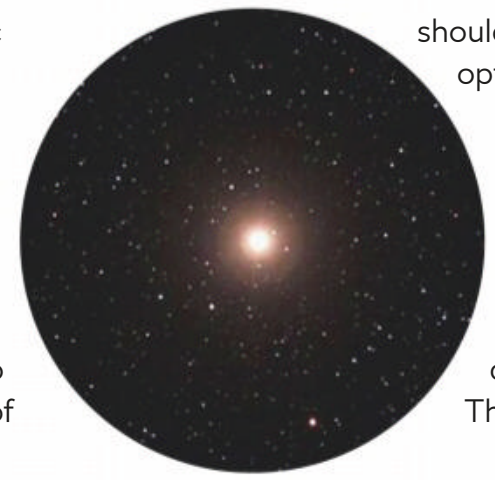


Mars reaches opposition in mid-October, a time when it appears largest and brightest for the current period of observation. A planet is said to be in opposition when the Earth lies directly between it and the Sun. The last Mars opposition was poor as seen from the UK since it was never all that high, but this time it occurs at a greatly improved altitude, which is all the more exciting.

During August Mars builds on the already impressive performance boost it got in July. Last month it moved from a compromised morning location to one where it appeared high in the sky in twilight. This month it manages to reach its highest position due south, in true darkness.

On 1 August, Mars shines at mag. –1.1, displaying its beautiful salmon-pink colour to the fore. Through a telescope it shows a 14 arcsecond disc on 1 August. The disc appears gibbous lit, with a phase of 86%.

On the morning of 9 August, a 73%-lit waning gibbous Moon can be seen close to Mars. As the sky begins to brighten on the morning of the 9th, both objects are a fraction over 3° apart. If you can stay with them throughout the day, then just before they set – say around 11:00 BST (10:00 UT) – the separation will be just over 1°. This is in daylight, of course, but at mag. –1.3, Mars should still be visible with an optical aid, given clear skies.



▲ **Enjoy observing Mars's beautiful salmon-pink colour**

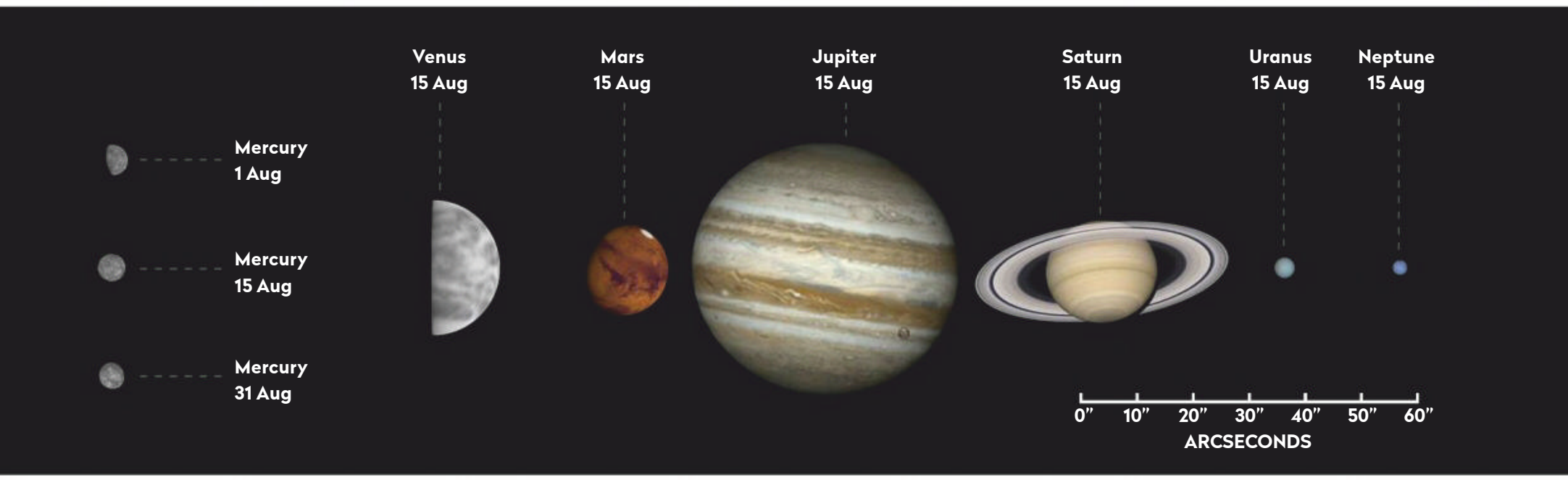
By the end of the month, Mars nestles within the 'V' pattern representing the cord tying the two fish together in the constellation of Pisces. This position allows the Red Planet to reach its highest position of 43°, due south around 04:15 BST (03:15 UT) while the sky is still dark.

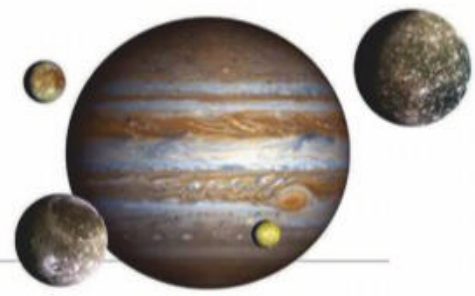
On 31 August Mars will be shining at mag. –1.8 and presents an 18 arcsecond disc when viewed through a scope.

PETE LAWRENCE X 3

The planets in August

The phase and relative sizes of the planets this month. Each planet is shown with south at the top, to show its orientation through a telescope





Mercury

Best time to see: 1 August, one hour before sunrise
Altitude: 3° (very low)
Location: Gemini
Direction: Northeast

Mercury was at greatest western elongation on 22 July, visible in the morning sky. At the start of August, it appears to head back towards the Sun, rising later with each passing day. On the 7th, Mercury is at mag. –1.3 above the northeast horizon, rising 70 minutes before the Sun. It'll probably only be possible to catch it for a few days after this; superior conjunction occurs on the 17th, after which Mercury reappears in the evening sky.

Venus

Best time to see: 31 August, 05:00 BST (04:00 UT)
Altitude: 24°
Location: Gemini
Direction: East

At the start of August, Venus rises three hours before sunrise. A brilliant morning beacon, it shines at mag. –4.3. Through a scope Venus appears 43%-lit and 27 arcseconds across.

On the morning of the 15th, Venus appears close to an 18%-lit waning crescent Moon.

The planet reaches greatest western elongation and dichotomy – geometrically 50%-illuminated – on 13 August (see page 43). On 31 August, mag. –4.1 Venus rises four hours before sunrise. Through an eyepiece it presents a 59%-illuminated gibbous disc.

Jupiter

Best time to see: 1 August, 00:00 BST (23:00 UT)
Altitude: 15°
Location: Sagittarius
Direction: South

Jupiter remains well presented during August, having reached opposition last month. Unfortunately, from the UK it remains low for telescope views. However, it does manage to reach its highest position in darkness all month long. Jupiter shines at mag. –2.6 at the month's start, dimming marginally to mag. –2.4.

Saturn

Best time to see: 1 August, 00:30 BST (23:30 UT)
Altitude: 16°
Location: Sagittarius
Direction: South

Like Jupiter, Saturn was also at opposition last month. It's currently located just east of Jupiter, and like its gas giant neighbour, remains low from the UK. Saturn shines at mag. +0.5 at the month's start, dimming to +0.6 by its close. The full Moon lies nearby on 2 August, and an 89%-illuminated waxing gibbous Moon revisits the planet on 29 August.

Uranus

Best time to see: 31 August, 04:00 BST (05:00 UT)
Altitude: 49°
Location: Aries
Direction: Just east of south

Morning planet Uranus almost reaches its highest point due south in darkness by month's close. It's on the threshold of naked-eye visibility at mag. +5.7.

Neptune

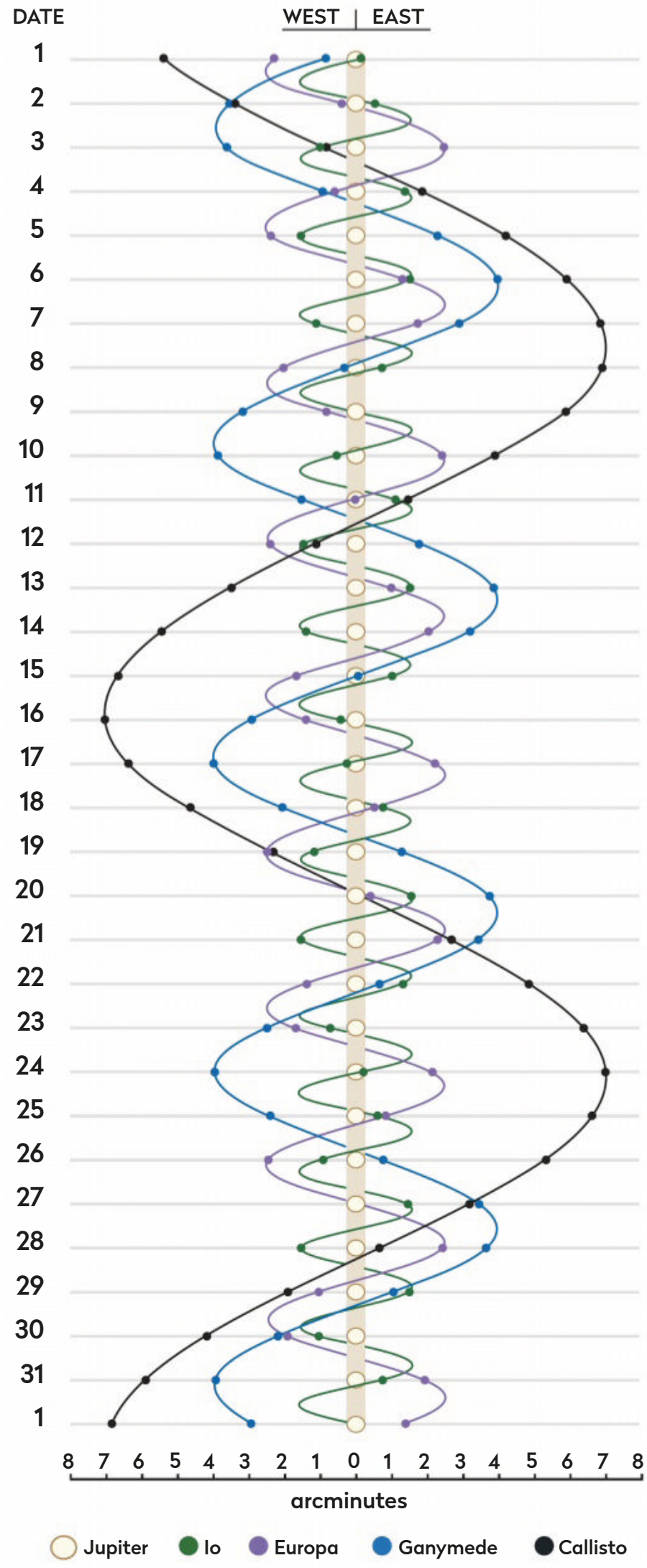
Best time to see: 31 August, 02:00 BST (01:00 UT)
Altitude: 32°
Location: Aquarius
Direction: South

Morning planet Neptune improves in appearance over the month, reaching its highest point due south in darkness from the middle of month onwards. It shines at mag. +7.8 and requires at least binoculars.

More **ONLINE**
Print out observing forms for recording planetary events

JUPITER'S MOONS: AUGUST

Using a small scope you can spot Jupiter's biggest moons. Their positions change dramatically during the month, as shown on the diagram. The line by each date represents 01:00 BST (00:00 UT).



THE NIGHT SKY – AUGUST

Explore the celestial sphere with our Northern Hemisphere all-sky chart

KEY TO STAR CHARTS

- Arcturus — STAR NAME
- PERSEUS — CONSTELLATION NAME
- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- THE MOON, SHOWING PHASE
- COMET TRACK
- ASTEROID TRACK
- STAR-HOPPING PATH
- METEOR RADIANT
- Circlet — ASTERISM
- PLANET
- QUASAR

STAR BRIGHTNESS:

- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER
- COMPASS AND FIELD OF VIEW
- MILKY WAY

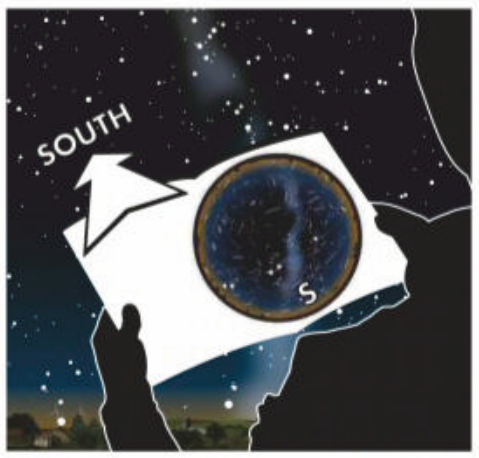
When to use this chart

1 August at 01:00 BST
15 August at 00:00 BST
31 August at 23:00 BST

On other dates, stars will be in slightly different positions because of Earth's orbital motion. Stars that cross the sky will set in the west four minutes earlier each night.

How to use this chart

1. Hold the chart so the direction you're facing is at the bottom.
2. The lower half of the chart shows the sky ahead of you.
3. The centre of the chart is the point directly over your head.



Sunrise/sunset in August*

Date	Sunrise	Sunset
1 Aug 2020	05:27 BST	21:05 BST
11 Aug 2020	05:43 BST	20:46 BST
21 Aug 2020	06:01 BST	20:24 BST
31 Aug 2020	06:18 BST	20:01 BST

Moonrise in August*

Moonrise times

1 Aug 2020, 20:12 BST	17 Aug 2020, 03:10 BST
5 Aug 2020, 22:13 BST	21 Aug 2020, 08:48 BST
9 Aug 2020, 23:10 BST	25 Aug 2020, 14:33 BST
13 Aug 2020, 00:04 BST	29 Aug 2020, 18:56 BST

*Times correct for the centre of the UK

Lunar phases in August

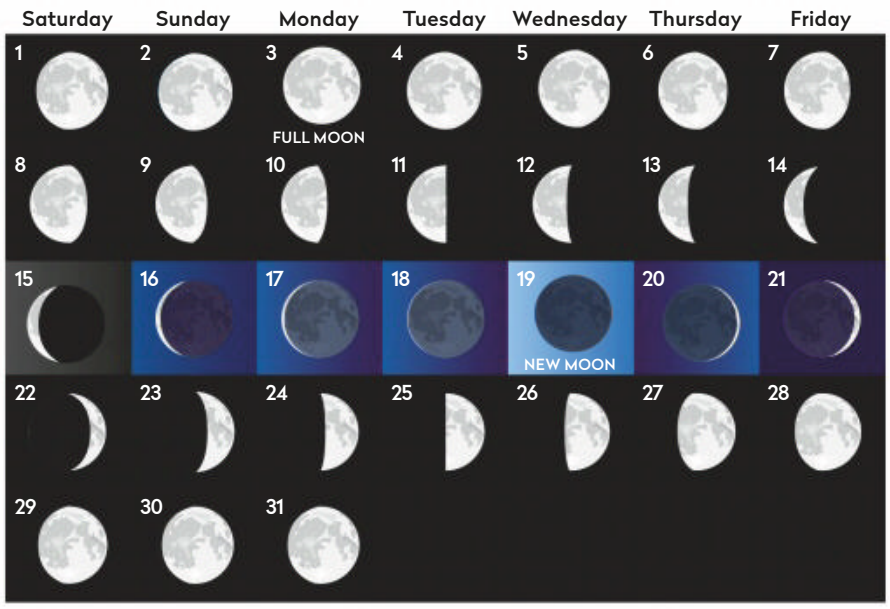
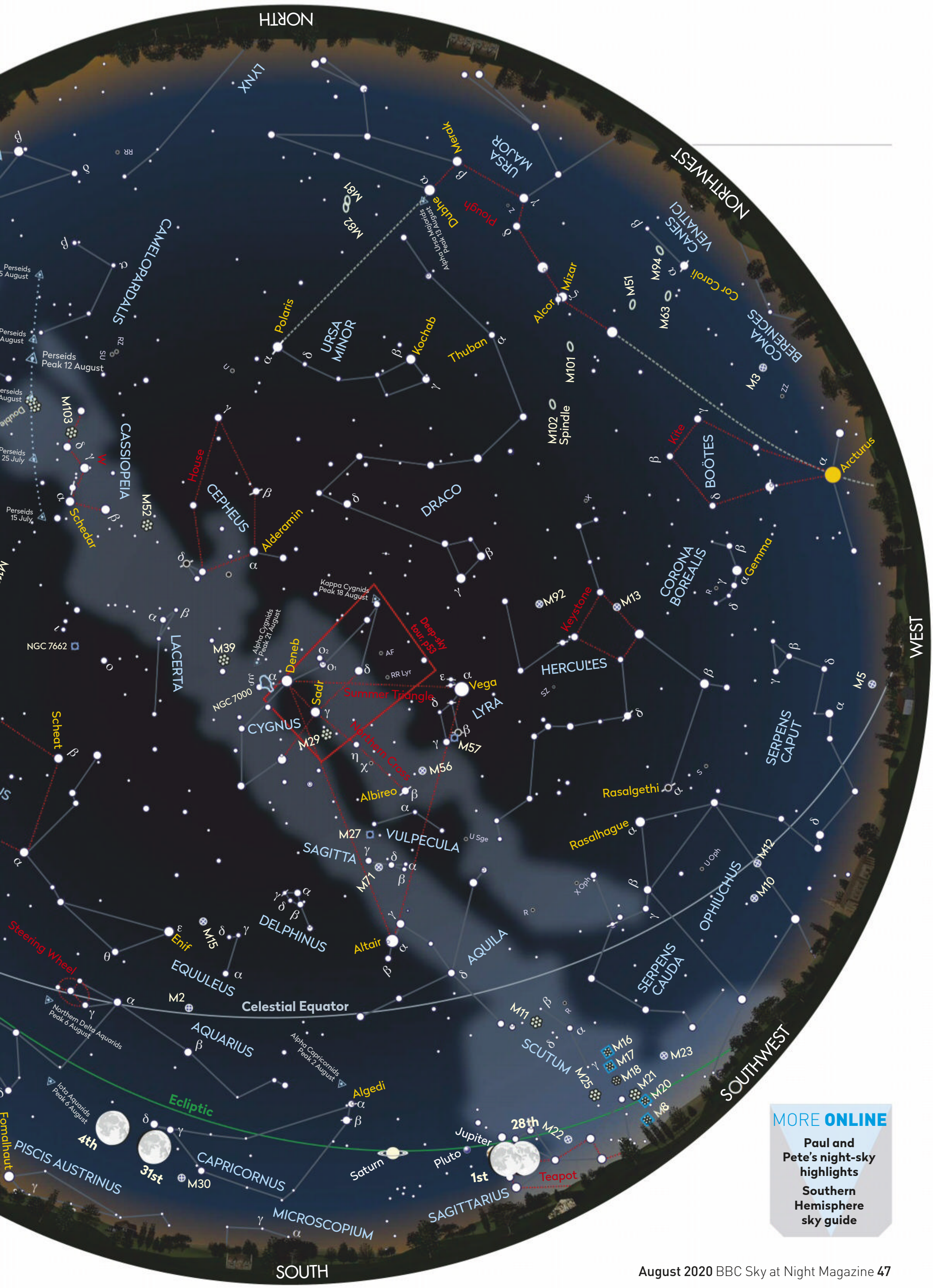


CHART: PETE LAWRENCE



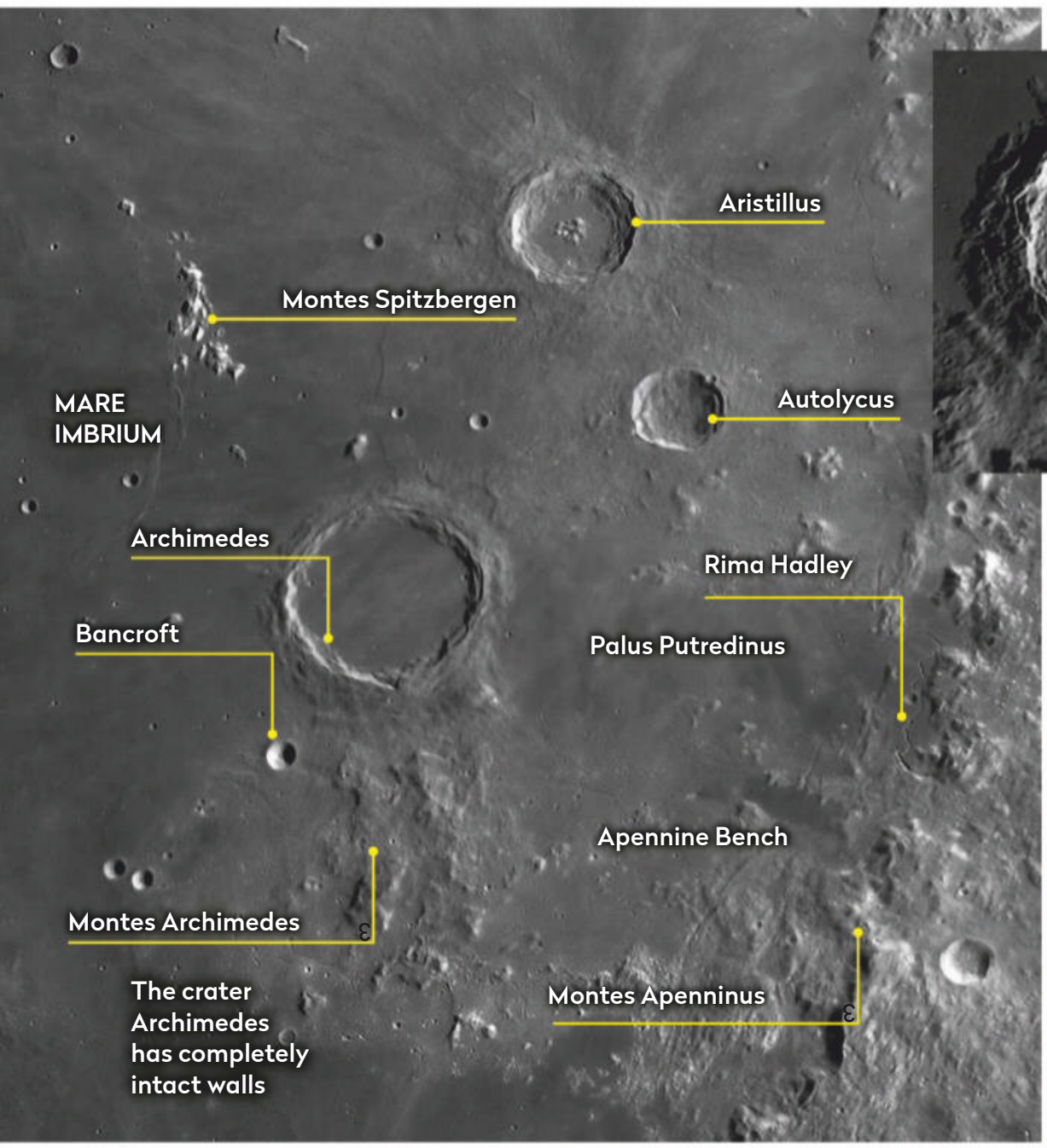
MORE **ONLINE**

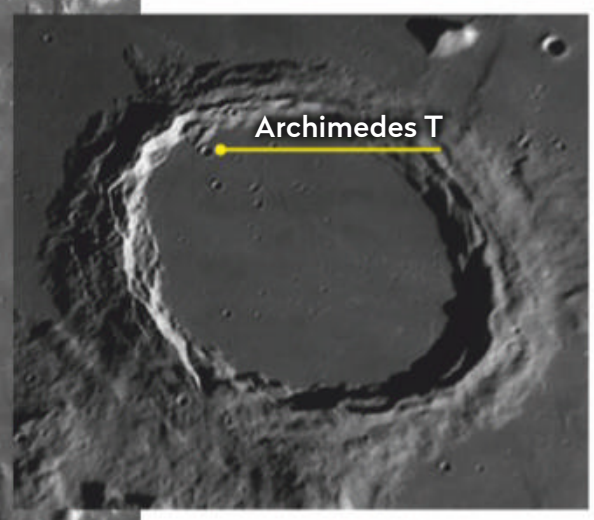
Paul and Pete's night-sky highlights

Southern Hemisphere sky guide

MOONWATCH

August's top lunar feature to observe





of these is 3km **Archimedes T**, which sits close to the inner northeast edge of Archimedes. If you can see this feature, look for another 2.6km unlabelled craterlet 8.5km to its southeast. A pair of even smaller features lie 10km to the east of this. Archimedes's floor appears striped with lighter material. This seems aligned with the younger crater **Autolycus**, the formation of which may have something to do with at least some of the stripes.

The appearance of Archimedes suggests its smooth lava floor was formed when cracks in the original crater floor allowed lava to well up inside the boundary rim. Despite being totally flooded, the walls of Archimedes are completely intact. They are also highly detailed, with steep inner terraces rising to a height of around 2km above the crater floor. The outside profile rises in a gentler but still steep fashion toward the rim's edge. The boundary material appears to connect to a bumpy, almost rectangular, mountainous region to the south known as **Montes Archimedes**.

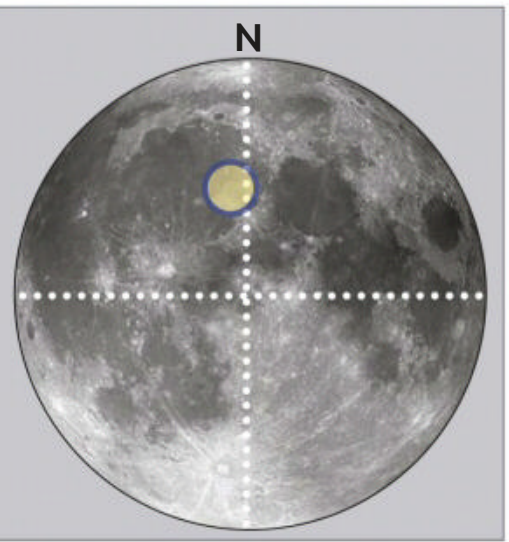
The surrounding region is equally as fascinating and contains varied examples of lunar geology. To the southeast is the flat region known as **Palus Putredinus**, an unwelcoming name meaning the 'marsh of decay'. This stretches into the foothills of the spectacular **Montes Apenninus**. A small enclave of lava close to the Apennines' edge contains the superb **Rima Hadley**, a sinuous rille which looks like a winding river engraved into the lunar surface.

The region south of Palus Putredinus, running from Montes Archimedes to Montes Apenninus, is known as the **Apennine Bench**. This region is defined by rough terrain cut by linear rilles and has been something of a puzzle: although it appears to be as old as the Imbrium Basin, it was probably formed from volcanic activity not associated with Mare Imbrium. Analysis of Apollo samples and via remote sensing satellites suggests the region has a unique chemical component called KREEP – potassium (chemical symbol K), rare Earth elements (REE) and phosphorous (chemical symbol P).

Located 150km north of Archimedes's centre is the impressive form of the isolated mountain chain called **Montes Spitzbergen**. The peaks rise to a height of around 1.4km above the surrounding surface of Mare Imbrium, which frames them perfectly. There are also some superb neighbouring craters: 40km Autolycus 150km to the east and 55km **Aristillus**, 100km north of Autolycus. These are well worth spending time investigating when the lunar terminator is nearby.

Archimedes

Type: Crater
Size: 83km
Longitude/latitude: 4.0° W, 29.7° N
Age: 3.2–3.8 billion years
Best time to see: First quarter (10–11 August) and six days after full Moon (26–27 August)
Minimum equipment: 50mm refractor



Archimedes is a large, lava-flooded feature located in the eastern region of **Mare Imbrium**. It's also the largest feature within the boundary of this immense 1,250km-diameter sea of solidified lava. Archimedes has a curious appearance with a rim that looks more like a raised ring surrounding a remarkably flat base. The crater's floor lacks any relief and there is no sign of any central mountain complex. Larger apertures or high-resolution imaging setups may be able to detect some of the multitude of craterlets that pockmark the smooth lava floor. The most notable

PETE LAWRENCE X 4

COMETS AND ASTEROIDS

As 1 Ceres reaches opposition on 28 August, we look back at its discovery

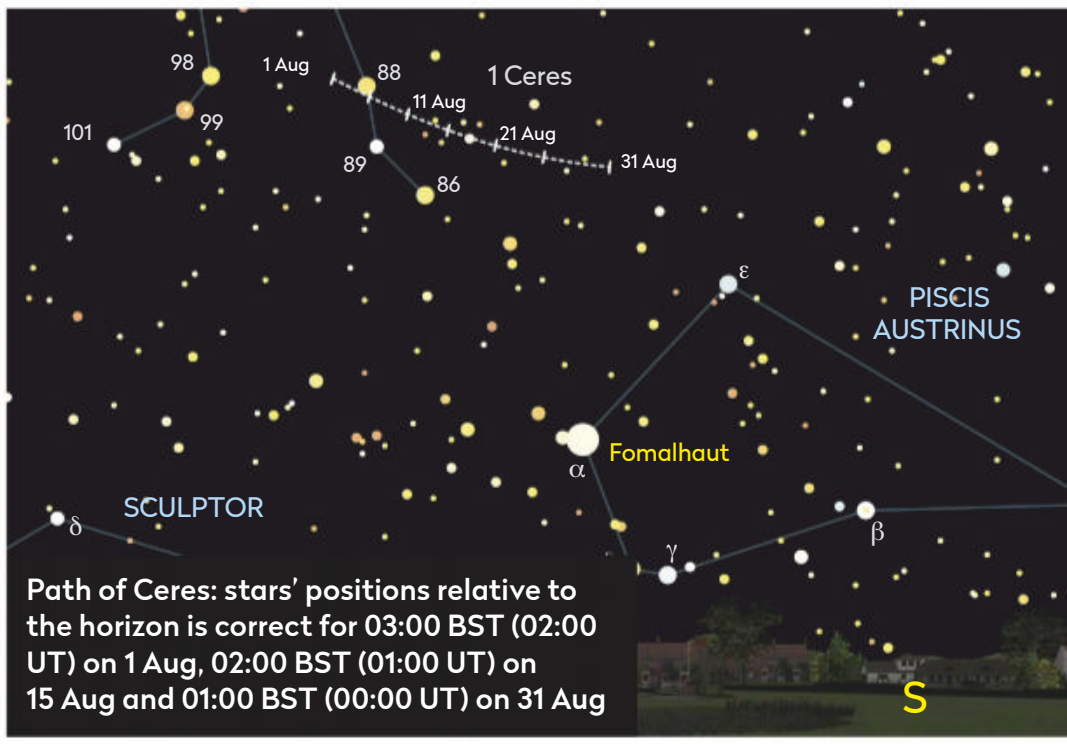
Ceres is a world of many designations; it was the first minor planet or asteroid formerly identified. This event occurred on 1 January 1801, its discoverer being an Italian monk called Giuseppe Piazzi. He was working at the Palermo Astronomical Observatory in Sicily at the time. While searching for a particular star, he observed moving Ceres and believed he had stumbled upon a comet. He followed the object for 41 days after which time he became ill, just as the Sun began to interfere with the field of view.

With just 41 days of observations, many doubted that the mathematics of the time could predict where Ceres would be after re-emerging from the Sun's glare. Mathematician Carl Friedrich Gauss saved the day, discovering a method for computing its orbit. He sent his predictions to astronomers Franz Xaver von Zach and Heinrich WM Olbers, who found the object on 31 December 1801.

Although Piazzi believed he had observed a new planet, other similar objects were soon discovered and it was realised that this was a new class of object. William Herschel coined the term asteroid, meaning 'star-like', to describe them.

In 2006 the International Astronomical Union, faced with the dilemma of several large Pluto-sized bodies discovered in the Solar System, created the new classification of 'dwarf planet'. This is the decision which demoted Pluto from planetary status while elevating 939km-diameter Ceres to a dwarf planet.

Ceres reaches opposition on 28 August. At the time it will lie within Aquarius and shine at mag. +7.7. It starts its August passage at mag. +8.1 close to mag. +3.7, 88 Aquarii. Consequently, it will be visible through binoculars all month. During favourable oppositions Ceres can reach mag. +6.6.



Path of Ceres: stars' positions relative to the horizon is correct for 03:00 BST (02:00 UT) on 1 Aug, 02:00 BST (01:00 UT) on 15 Aug and 01:00 BST (00:00 UT) on 31 Aug

STAR OF THE MONTH

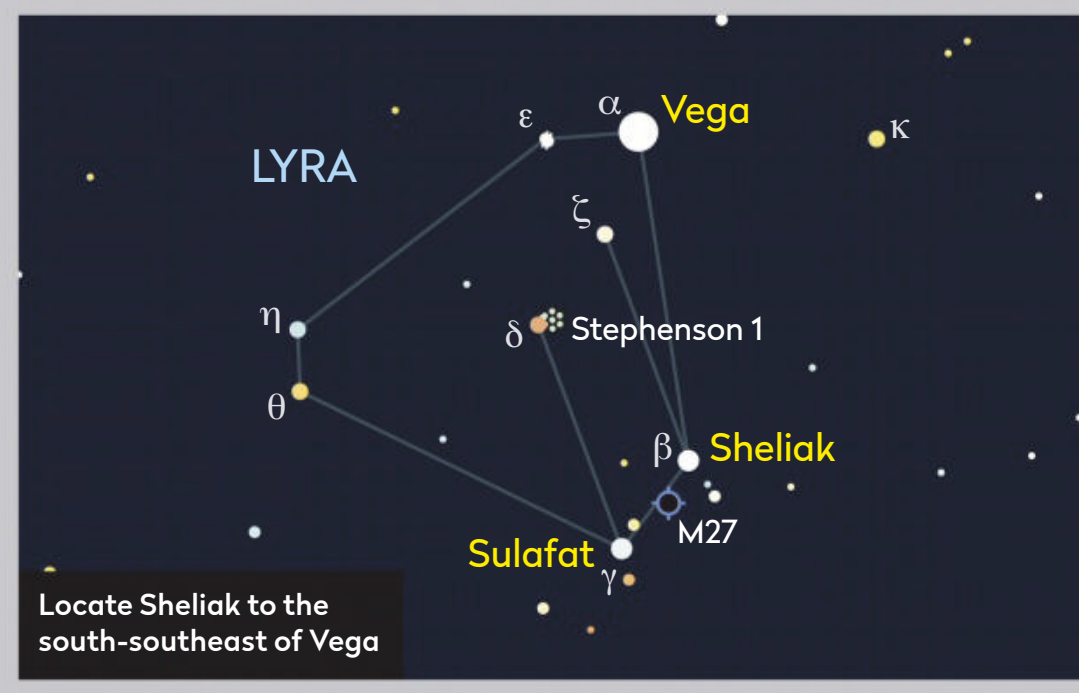
Sheliak, a multiple star system in Lyra

Lyra, the Lyre, is a distinctive summer constellation: its alpha star Vega is the fifth brightest in the night sky. Southeast of Vega is a distinct squashed diamond pattern formed from Sheliak (Beta (β)), Sulafat (Gamma (γ)), Delta (δ) and Zeta (ζ) Lyrae. Sheliak is the mag. +3.3 star marking the diamond's southwest corner.

Sheliak is actually a multiple star system that is around 960 lightyears away. The system has three main components: Beta Lyrae A (variable magnitude, +3.3 to +4.3), B (mag. +7.2, 46 arcseconds from A) and C (mag. +9.9, 86 arcseconds away). Stars B and C are singles, while A is another multiple.

Beta Lyrae A comprises an eclipsing binary pair identified as Aa and a single star Ab. The former, labelled Aa1 and Aa2 consists of a B7 giant and a B0.5 dwarf star. The giant is 8,300 times more luminous and 14.4 times larger than the Sun. The dwarf is 27,700 times more luminous and six times larger than the Sun.

Their mutual separation distance is around a quarter of an Astronomical Unit (the average Sun-Earth distance). At this proximity, tidal forces result in mass transfer from the giant to the dwarf, and the giant is distorted towards the smaller but heavier star. Its shape will resemble a teardrop, the pointed end drawn out towards the dwarf star. The transferred material passes through the teardrop's point ending in a spiralling accretion disc around the dwarf star.



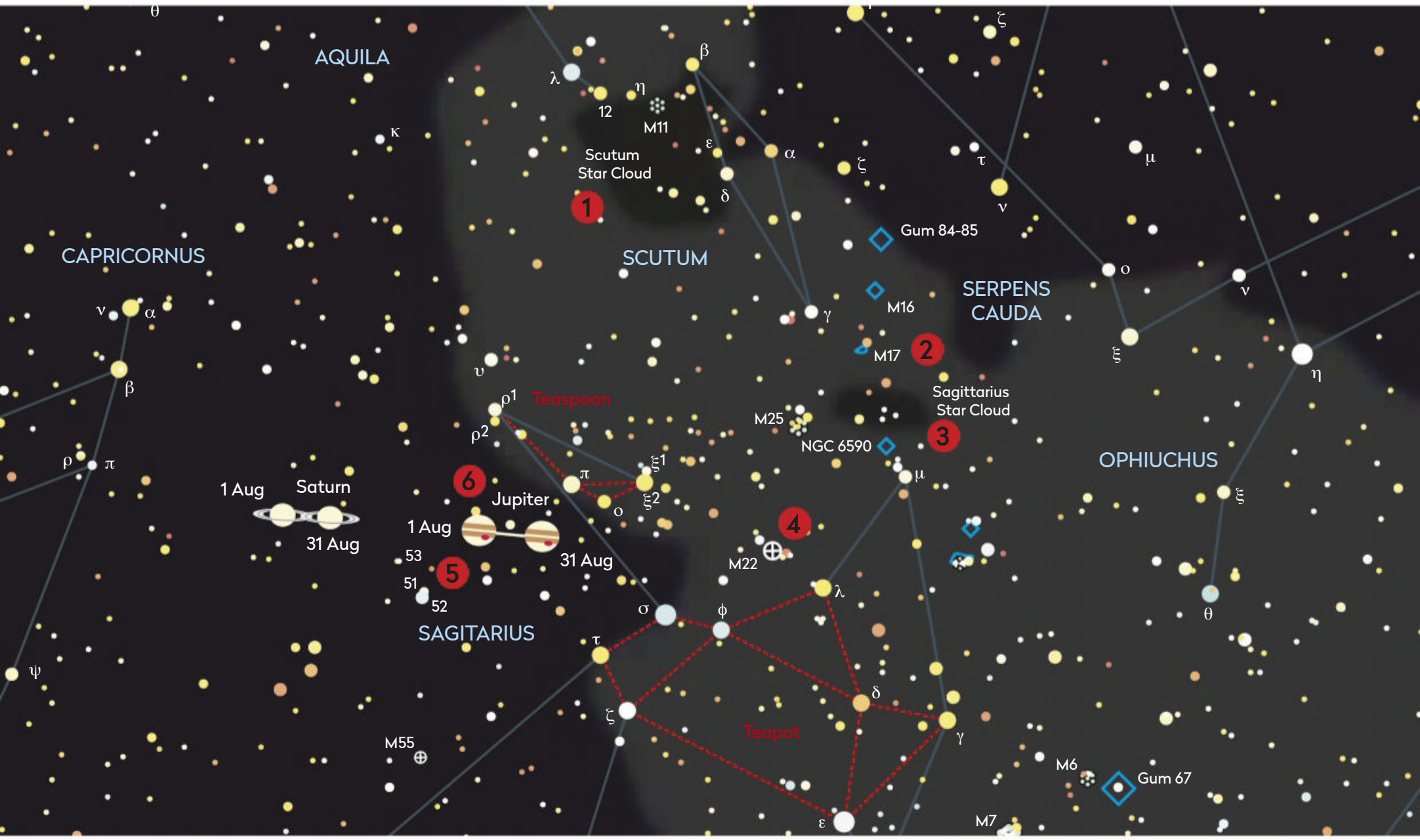
Locate Sheliak to the south-southeast of Vega

The orbital period of Beta Lyrae Aa is 12.9 days. Their line of sight is such that the stars exhibit a brightness variation over 6.5 days, each star mutually eclipsing the other. The hot accretion disc around the dwarf causes variation in the depth of alternating minima. The result is one normal dip to mag. +3.8, then a deeper one to mag. +4.3.

BINOCULAR TOUR

With Steve Tonkin

Discover summer's most spectacular wide-field sights, including open cluster M11



1. The Scutum Star Cloud

10x 50 We'll begin with the astonishingly rich star field in the northeast quarter of Scutum. It's so easy to find that it has been mistaken for a real cloud on a clear night. Look for the ripples of stars, formed by the indistinct dark nebulae that weave among them. You should also see the even richer condensation of nearly 3,000 hot blue stars that forms the densest of all open clusters, M11, the Wild Duck Cluster. ☐ **SEEN IT**

2. The Swan Nebula M17

15x 70 Next, identify Gamma (γ) Scuti and pan 2.5° to the southwest, where you will find a misty patch that Charles Messier described as, "A train of light without stars, in the shape of a spindle, of 5 or 6 minutes in extent." Keep it centred while you use averted vision to reveal a small hook-like extension extending south from the top right-hand side of the patch, like an inverted tick. ☐ **SEEN IT**

3. The Sagittarius Star Cloud

10x 50 M24 lies a bit more than halfway from Gamma (γ) Scuti to Mu (μ) Sagittarii. It is another bright patch of light that is easily mistaken for a cloud just above the horizon. It is part of the Sagittarius Arm of the Milky Way that is partly obscured by dust. Easily the richest vista visible in 10x50s, it has around 1,000 stars that can be resolved in a single field of view. ☐ **SEEN IT**

4. M22

10x 50 Find Kaus Boralis (Lambda (λ) Sgr), the 'peak' of Sagittarius's Teapot asterism, and put it at four o'clock in the field of view. M22, the largest globular cluster visible from the UK, should be obvious near the centre. This beautiful object shows a much brighter core, very much like the coma of a comet, making it clear why Charles Messier included it in his catalogue of objects that were not to be mistaken for comets. ☐ **SEEN IT**

5. 52 and 53 Sagittarii

10x 50 Our next targets are easy pairs of double stars. The first is the white pair, 52 (mag. +4.6) and 51 (mag. +5.6) Sagittarii, which are 13 arcminutes apart. One is slightly bluer than the other – can you tell which? 53 Sgr shines at mag. +6.3, a third of a magnitude fainter than its orange companion, 4 arcminutes to the east. Both are line-of-sight associations and not true binary stars. ☐ **SEEN IT**

6. Jupiter

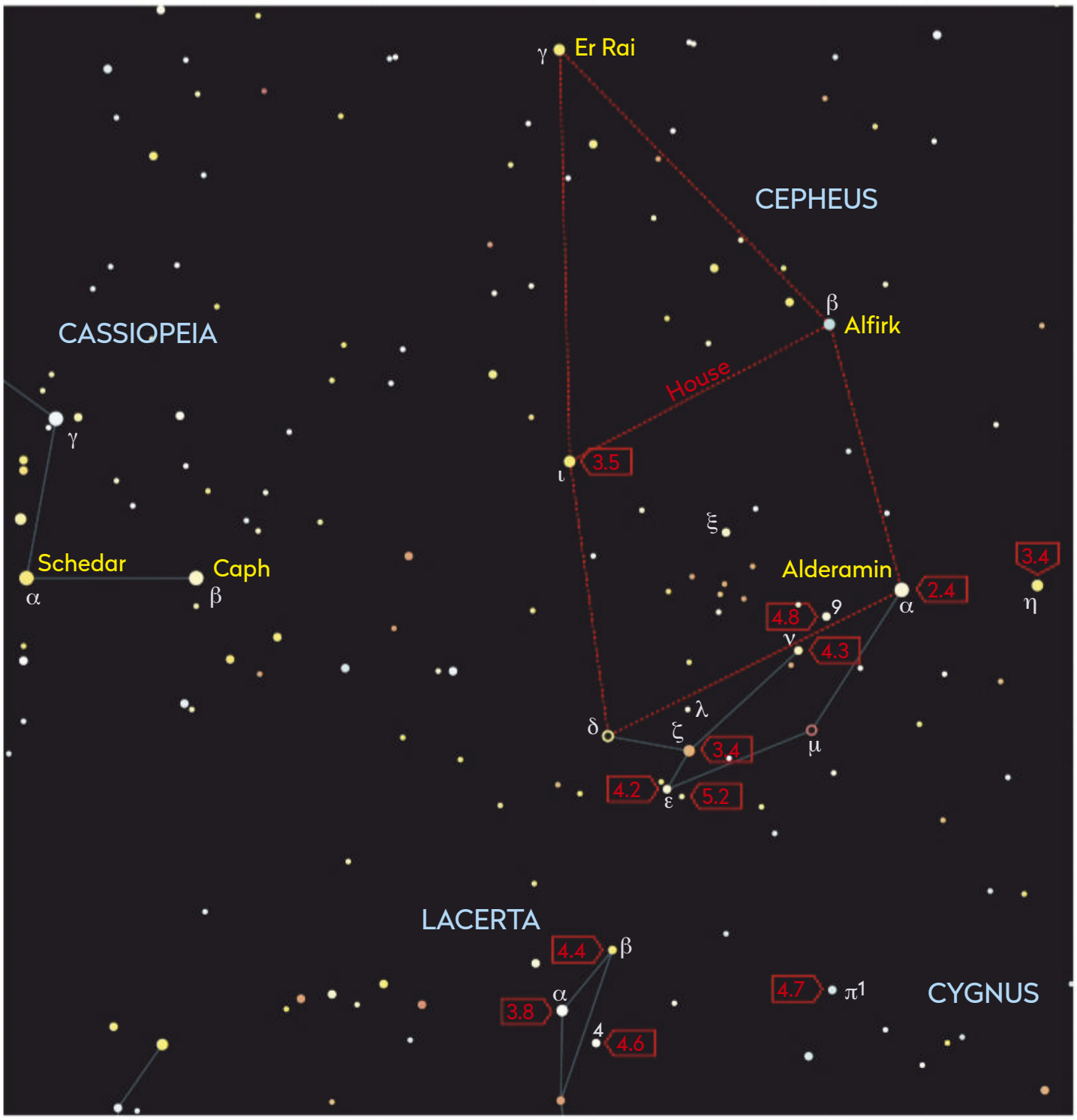
10x 50 You won't see Jupiter's surface detail in small binoculars, but it's easy to watch the stately dance of its Galilean moons. The dazzling planet can impair the view, so ensure your optics are clean and focused. Start with Ganymede and Callisto, and use the chart on page 45 to find when they are at greatest elongation and furthest from Jupiter's glare. ☐ **SEEN IT**

☑ Tick the box when you've seen each one

PETE LAWRENCE X 2

THE SKY GUIDE CHALLENGE

Can you observe and estimate the variability of Delta Cephei?



▲ Bright idea: use this comparison chart to locate Delta Cephei, and estimate and plot its brightness over the period of at least a month

It's easy to spot Delta Cephei with the naked eye

Delta (δ) Cephei is a famous variable star in the constellation of Cepheus, the King. At this time of year it's well placed, providing a good opportunity to see it 'doing its thing' which is, of course, varying in brightness. This month's challenge is to record this variability to reveal the true nature of this incredibly important star.

At this point, you may be wondering why we're elevating the status of Delta Cephei so much, after all, there are plenty of other stars in the night sky that exhibit variability. While that's perfectly true, Delta Cephei holds a special place because it's the prototype of an important class of variable stars called Cepheid variables.

Interestingly, it wasn't the first of its kind identified. That honour goes to Eta (ε) Aquilae, which was discovered on 10 September 1784. Delta Cephei was first recorded by John Goodricke on 19 October 1784, with regular follow up observations made through to the end of that year and into the first part of 1785. His write up of the variability of Delta Cephei was formally published on 1 January 1786.

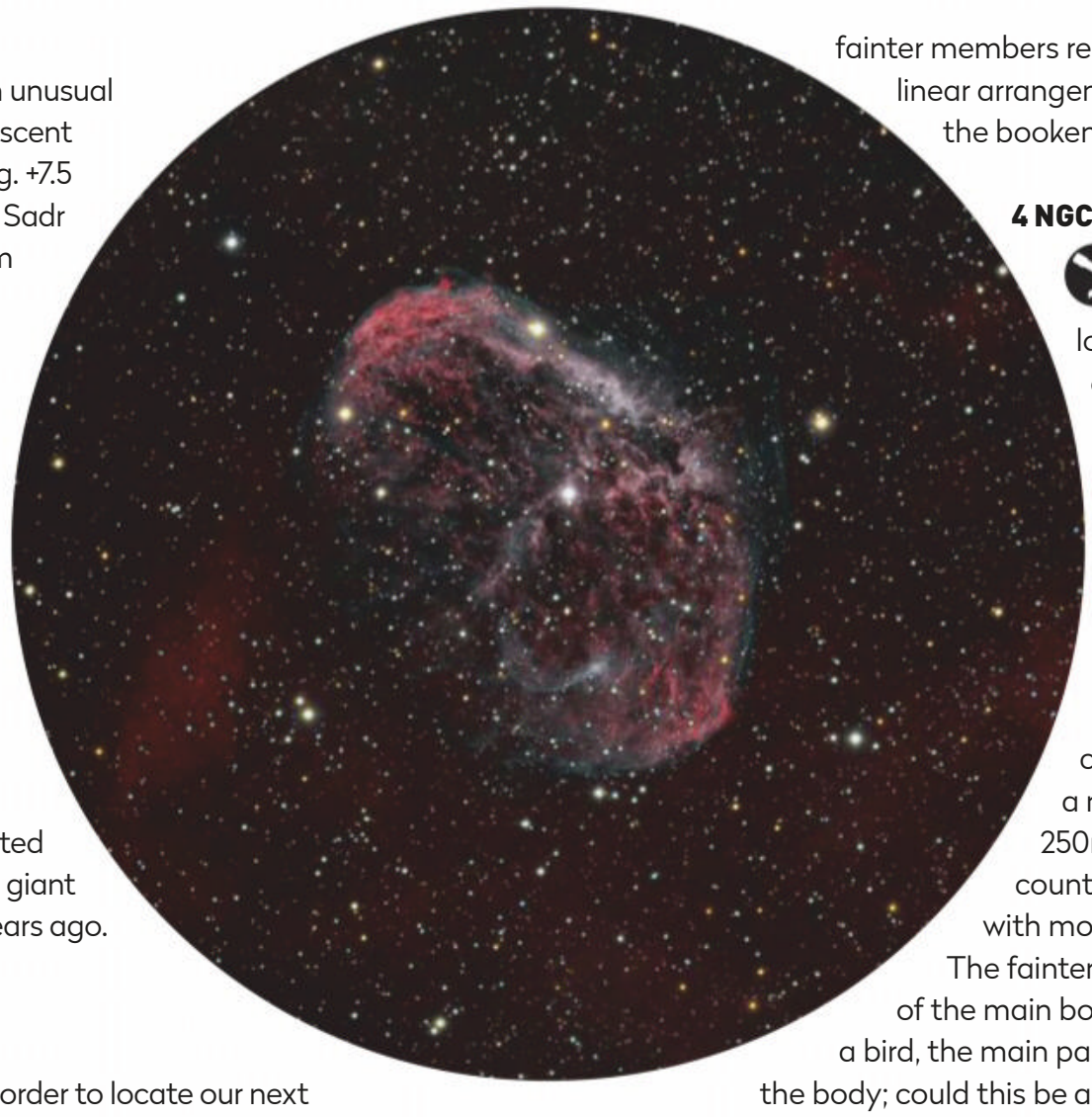
The star's variability is intrinsic, meaning it comes from within. It pulsates radially so that both its diameter and luminosity vary with time. The period of variability is stable in both frequency and amplitude. In 1912, Henrietta Swan Leavitt identified that the pulsation period of a Cepheid variable was directly linked to the star's luminosity.

This discovery was profound and the reason why classic Cepheids have such an elevated status. Basically, once you have identified a Cepheid, by determining its variability period you can work out what luminosity it should have. This is determined by Swan Leavitt's discovery. Knowing how bright a star should appear can then be used to determine how distant that star must be in order to look as bright as it does to us. For this reason, Cepheid variables are sometimes referred to as 'standard candles'.

Your challenge is simply to estimate the brightness of Delta Cephei using our comparison chart (left) and plot this variability on a graph with magnitude along the vertical axis and time along the horizontal axis. Ideally, you'll need to do this over a period of a month or more to get a decent light curve. This will show you the variability repeating itself. Weather will play a part here of course, but as Delta Cephei is easy to spot with the naked eye, it's possible to make an observation fairly quickly if any clear gaps appear. If you manage to determine the period, you've just repeated a fundamental observation which changed the way we figure out how far external galaxies are from us.

DEEP-SKY TOUR

We explore objects in Cygnus, from the Swan's body to the tip of its western wing



▲ **Begin this month's tour with the Crescent Nebula, NGC 6888, a spectacular emission nebula in the constellation of Cygnus**

DIETER BEER/PATRICK HOCHLEITNER/CCDGUIDE.COM, CHART BY PETE LAWRENCE

1 NGC 6888

We begin with an unusual favourite, the Crescent Nebula, NGC 6888. This mag. +7.5 object sits 2.7° southwest of Sadr (Gamma (γ) Cygni). A 250mm scope reveals the brightest section to resemble a weak light arc between the brightest and dimmest members of a mag. +7.2, +7.5 and +8.5 star triangle. Larger apertures extend the arc to the north of the western triangle star, WR 136. NGC 6888 represents the interaction between the fast stellar wind from WR 136 catching up with slower moving material ejected when the star became a red giant over a quarter of a million years ago. ☐ **SEEN IT**

2 Collinder 419

Return to Sadr in order to locate our next target, a complex area of sky full of faint stars and weak nebulosity. Collinder 419 is a mag. +7.6 open cluster which lies 0.9° from Sadr, a fraction south of the line joining Sadr to the western tip of Cygnus's wing marked by Rukh (Delta (δ) Cygni) – so more or less northwest of Sadr. The cluster is tricky to see at first because it's dominated by the double star Struve 2666. It's best to centre on Struve 2666 and then increase power; magnifications of 100x to 150x should reveal the faint powdering of stars that is Collinder 419. ☐ **SEEN IT**

3 NGC 6910

Sadr can also be used for our next target, open cluster NGC 6910, which is located a fraction over half a degree to its north-northeast. With an integrated magnitude of +6.6, NGC 6910 should be easy to find in any size of instrument, but watch out for the rich star background, as it can make it a little harder than normal to pick open clusters out of the background. This is a nice cluster, bookended by a pair of brighter stars shining at mag. +7.3 to the northwest and +7.0 to the southeast. A 150mm scope shows about a dozen fainter stars running between the brighter pair. A 250mm scope almost doubles the star count, the fainter members remaining confined to a linear arrangement running between the bookending pair. ☐ **SEEN IT**

4 NGC 6866

Next is open cluster NGC 6866, located 0.9° northeast of the mid-point along the line between Sadr and Rukh. It's a mag. +7.6 cluster, around 7 arcminutes in size. NGC 6866 appears to contain around 20 stars through a 150mm instrument. The main concentration of the cluster appears stretched in a north to south direction. A 250mm scope doubles the star count to around 40 members, with more fainter stars on view. The fainter stars to the east and west of the main body appear like the wings of a bird, the main part of the cluster forming the body; could this be a mini-Cygnus? ☐ **SEEN IT**

5 NGC 6811

Our penultimate target is another cluster, but with a twist. NGC 6811 is a mag. +6.8 object measuring 15 arcminutes across. A small scope resolves it, revealing around 50 members, including a lot of white stars along with some striking red ones. The core of NGC 6811 is quite underpopulated and if you increase magnification it gives the impression that the inner portion is dark, almost as if it has a hole inside it. This has given it the informal title of 'The Hole in the Cluster'. Estimated to be around 700 million years old, NGC 6811 lies about 3,600 lightyears from Earth. It sits against a bright portion of the Milky Way but, thanks to its rich star count, manages to stand out well. ☐ **SEEN IT**

6 NGC 6826

Our final target is a planetary nebula known as NGC 6826, which lies 5.4° due north of Rukh on the northern (trailing) edge of Cygnus's western wing. The nebula has an integrated magnitude of +8.8, spread into an oval 27x24 arcseconds across. NGC 6826's central star is mag. +10.7 and bright enough to interfere with the view. So, if you look directly at this star using a small instrument the nebula disappears, whereas if you use averted vision the nebula pops back into view. Although this effect is not completely unique to NGC 6826, it has become known informally as the Blinking Nebula. Thanks to ESA's Gaia mission we know it is 5,136 lightyears away. ☐ **SEEN IT**

This Deep-Sky Tour has been automated
ASCOM-enabled Go-To mounts can now take you to this month's targets at the touch of a button, with our Deep-Sky Tour file for the EQTOUR app. Find it online.

More **ONLINE**

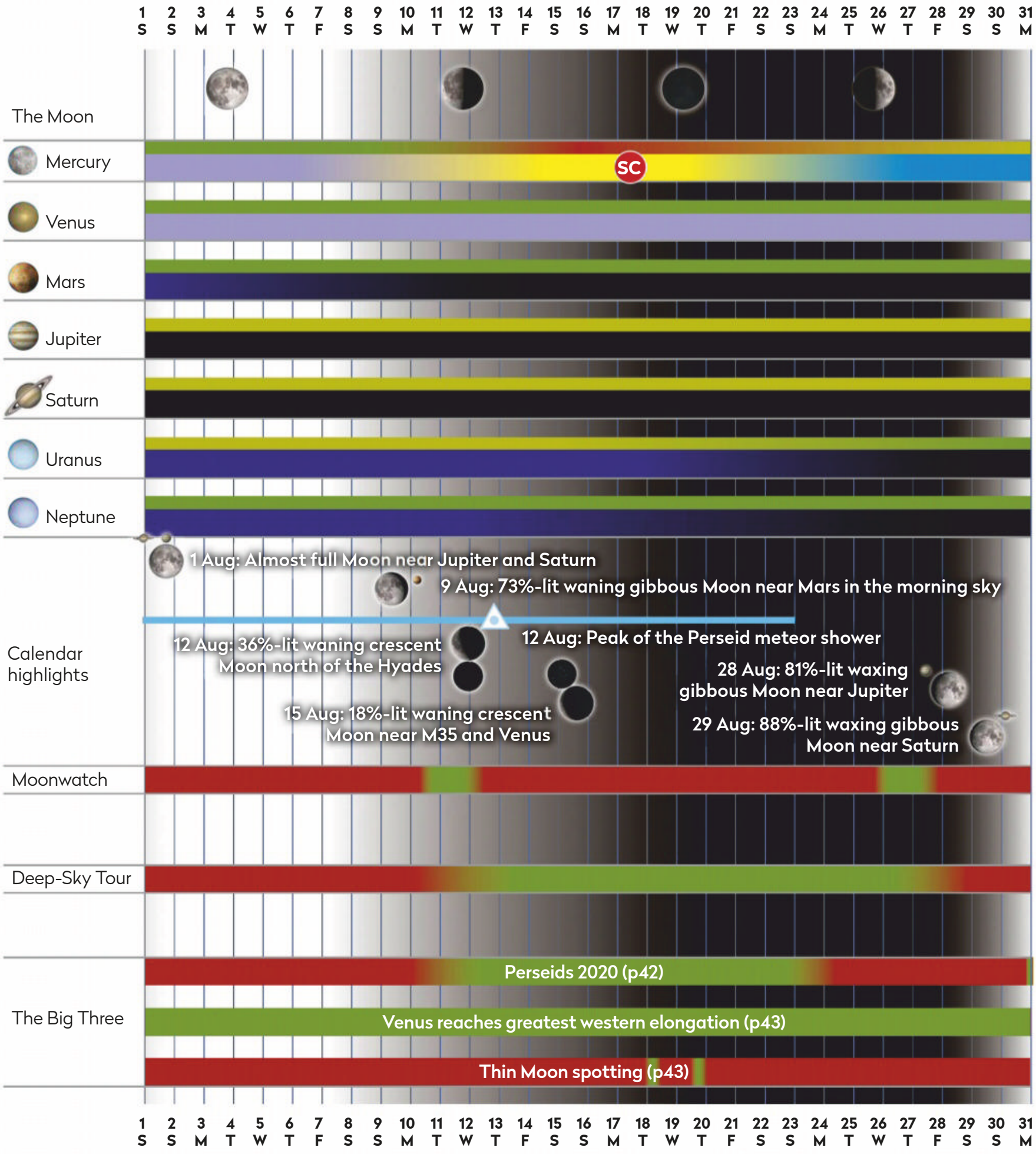
Print out this chart and take an automated Go-To tour. See page 5 for instructions.

CYGNUS

19h30m
+50°
ι
6
NGC 6826
5
NGC 6811
20h00m
+45°
19h00m
N
W
S
E
5°
2°
δ
Rukh
+50°
19h30m
+40°
NGC 6819
O2
O1
4
NGC 6866
20h30m
2
Collinder 419
Basel 6
1
Deneb
α
Sadr
γ
NGC 6888
NGC 6910
3
NGC 6871
+45°
Berkeley 86
+35°
IC 4996
Biurakan 2
M29
NGC 6883
IC 5067
20h30m
+40°
+35°

AT A GLANCE

How the Sky Guide events will appear in August



KEY

Observability

Optimal | Poor

Best viewed

Morning twilight | Daytime | Evening twilight | Night

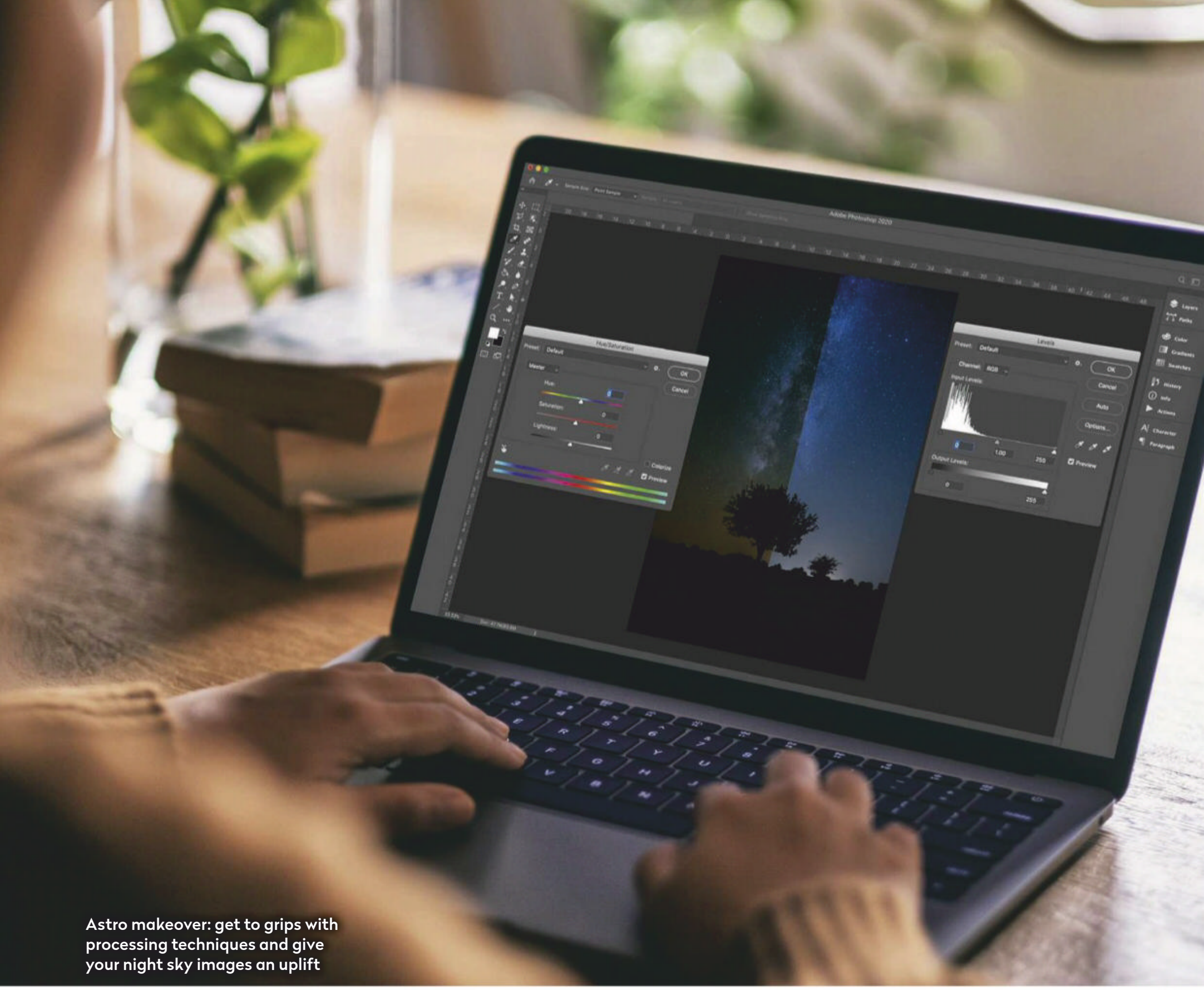
Sky brightness during lunar phases

Dark (first quarter) | Light (full Moon) | Dark (last quarter) | Total darkness (new Moon)

- IC — Inferior conjunction (Mercury & Venus only)
- SC — Superior conjunction
- OP — Planet at opposition
- Meteor radiant peak
- Planets in conjunction

- Full Moon
- First quarter
- Last quarter
- New Moon

CHART BY PETE LAWRENCE



Astro makeover: get to grips with processing techniques and give your night sky images an uplift

FARKNOT_ARCHITECT/ISTOCK/GETTY IMAGES

Transform your astrophotos with image processing

Charlotte Daniels is an amateur astronomer, astrophotographer and journalist

Much of the work on an astro image takes place after it's been captured, **Charlotte Daniels** introduces the software, techniques and adjustments for beginners

Astrophotography is a steep learning curve for everyone, with lots of questions to consider. What kind of images do you want to capture? What kind of equipment do you have (and what sort do you need)? What are the best camera settings to use? Then there's the late nights to consider, the time required and of course the weather. Yet astrophotography is a labour of love and when it goes right, it can be extremely rewarding.

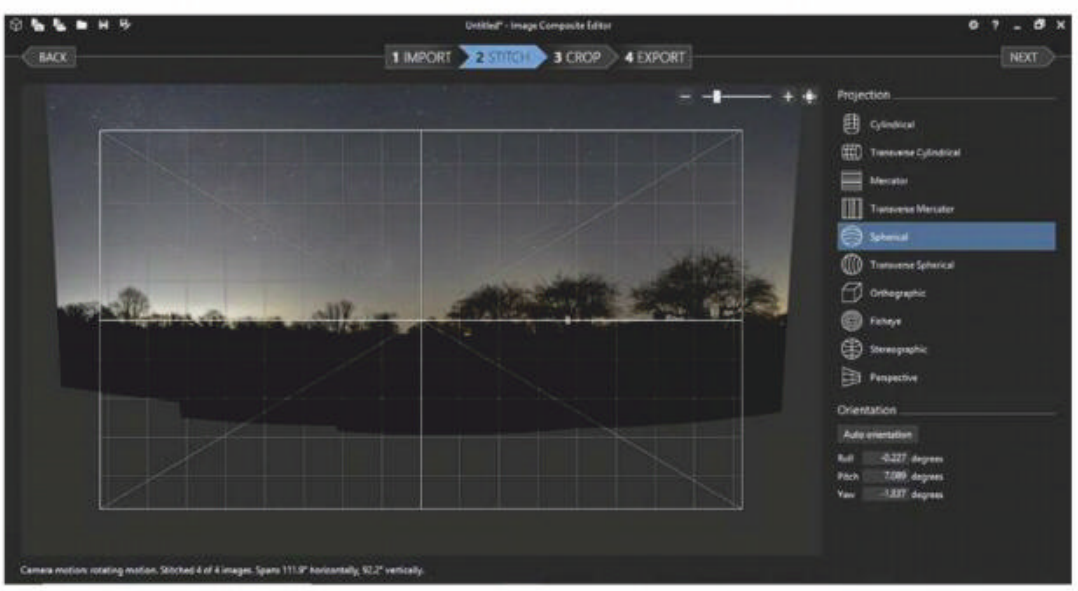
While the logistics of imaging are one set of challenges, knowing what to do with the data in the morning is another. This is where image processing – enhancing a digital image to improve its visual appeal with computer programs like Adobe Photoshop or GIMP – comes in. It's a major part of an astrophotographer's skill set, and here we're going to take a beginner's look at the software needed and what to do with it to achieve great results on nightscapes, planetary photography and deep-sky images. ▸

Dorset delight: a nightscape capture of the Milky Way presents a great opportunity to try your processing skills

Nightscapes

Simple to take, these astro images are a great way to practise processing

What is a nightscape photo? It can be a landscape at night and it can also be a wide-angle photo of the night sky capturing the Milky May, noctilucent clouds, Moon sequences or the aurora. Nightscapes are often achieved using single, untracked images, meaning that you can capture these without using a mount that follows the apparent movement of the sky. Each of the above can be captured using basic equipment; either a DSLR with a lens, or a smartphone, and a tripod.



▼ Figure 1: after importing your images into ICE they are ready to 'Stitch' and the type of panoramic view can be selected

SCHROPTSCHOP/ISTOCK/GETTY IMAGES, CHARLOTTE DANIELS X 6

Depending on the equipment, exposure times can be up to 30 seconds before the stars start trailing noticeably. To find out the approximate exposure time before stars stop looking sharp, use the '500 Rule'. Dividing 500 by the focal length of your lens provides the longest exposure time for your setup.

Processing nightscapes (especially single, unstacked images) often requires just a minor stretch to the light curve in Adobe Lightroom or Photoshop, using the sliders rather than specific or niche settings.

A popular option for nightscapes, however, is to blend several side-by-side images into a panorama. Many Milky Way images are blended mosaics or panoramas, consisting of several images pasted together. Stitching images together requires software such as Microsoft Image Composite Editor (ICE) – a program that is simple to use. Simply open the software, click 'New Panorama From Images' and upload the exposures (see figures 1 and 2). The resulting image can then be saved and edited in Photoshop or Lightroom.

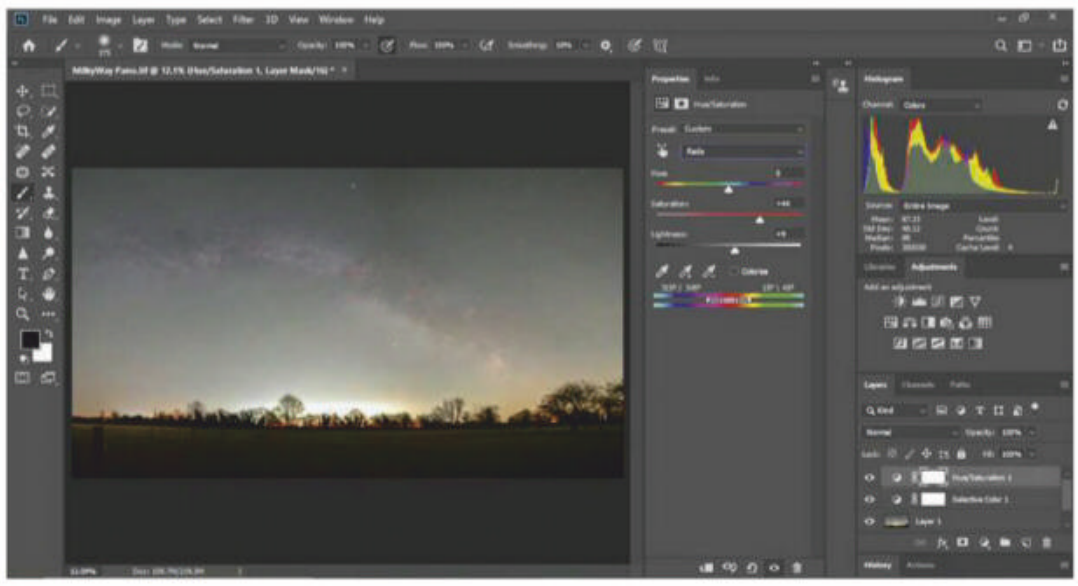
◄ Figure 2: when your images are successfully stitched in ICE you can use 'Crop' to indicate your panorama's size

nightscapes, which allow for longer exposures that capture fainter stars. Processing these images is largely the same, although if taking images to stack (which reduces noise), stacking software is needed before processing (see 'Planets and Moon' for more on this). ►

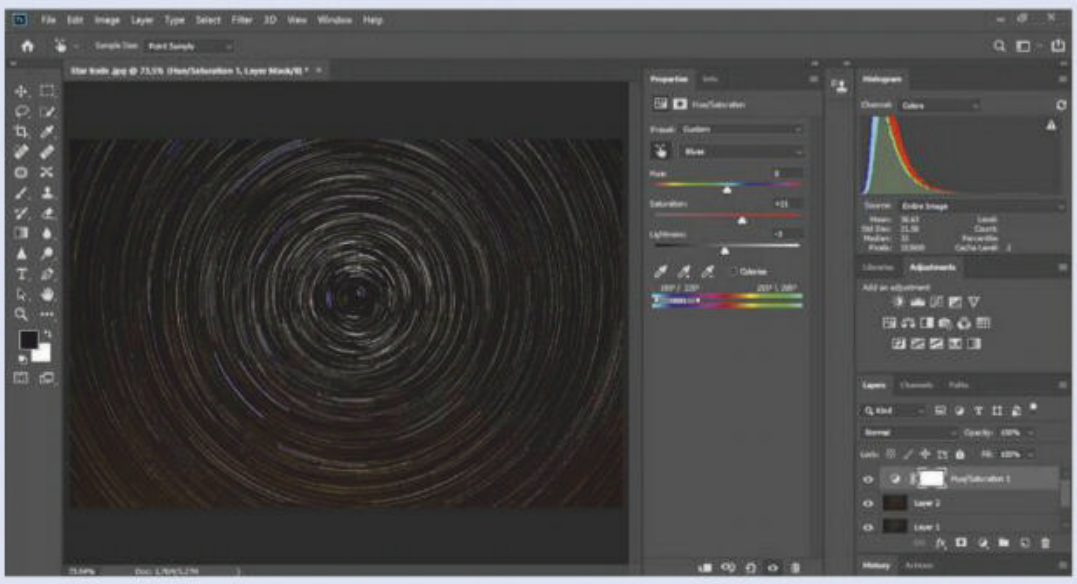
Once the image has been stitched together, we suggest adjusting it in Photoshop with the 'Brightness/Contrast', 'Hue/Saturation' and 'Selective Colour' sliders. 'Selective Colour' is useful for removing sky glow (such as oranges and pinks) and magenta from a nightscape. These colours can diminish the impact of a Milky Way shot, so take your time on adjusting these (see figure 3).

Remember not to go too far – moving the sliders too much risks making the image noisy (revealing unwanted artefacts), particularly if it is a single image rather than multiple images 'stacked' together. Oversaturation or over-stretching, so that stars lose their colour or the sky appears too blue, can leave nightscapes looking artificial.

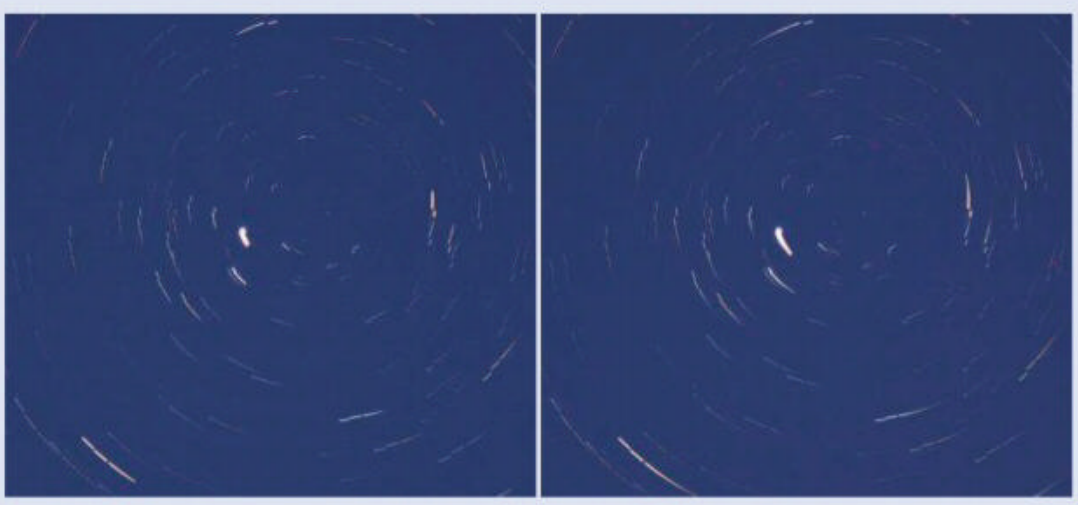
If you have a star tracker or a tracking mount that moves with the sky it's also possible to do tracked



▲ Figure 3: in Photoshop you can make careful adjustments to the colours and intensity of your panorama by using the 'Hue/Saturation' sliders



▲ Use Photoshop to bring out the colours in your star trails...



▲ ...and freeware such as Startails (www.startrails.de) to merge your images

Star trails

An easy astro image which can be achieved on some smartphones

Star trails are made up of multiple merged images, each of around 30- to 60-second exposures. These can either include a foreground for effect or they can be a full circle of star trails with Polaris in the centre. To achieve a decent curvature on the trails, set aside two to three hours to gather enough images.

The longer exposures mean that ISO levels need to be managed – if the ISO setting is too high, the final image may be noisy or light polluted. Here, get to know the camera; it might be that you prefer the effect of a 25-second exposure at ISO 3200 over a 40-second exposure at ISO 800. It will also depend on local surroundings and the time of year you're imaging. If using an intervalometer to control when the shutter goes off, set a short time between exposures – 1 or 2 seconds to prevent gaps disrupting the trails.

The free-to-use software Startrails allows you to merge your images. Once downloaded, simply click the 'Open images' icon to import. Make sure you select 'Lighten-screen-blend' in 'Blend mode' to smooth the trail lines properly. Your merged star trails can be uploaded into Photoshop for colour adjustment with 'Hue/Saturation' and 'Brightness/Contrast'. It's easy to overdo the contrast or under-saturated stars, but there are plenty of different colours to be drawn out.

Planets and the Moon

Images of Solar System bodies benefit from stacking images together

◄ Far left: an image of Jupiter taken with a CCD camera and processed from stacking the best 600 of 1,100 frames in RegiStax; Left: a mosaic of the waning Moon made of 67 panes processed in RegiStax, with further contrast processing in Photoshop

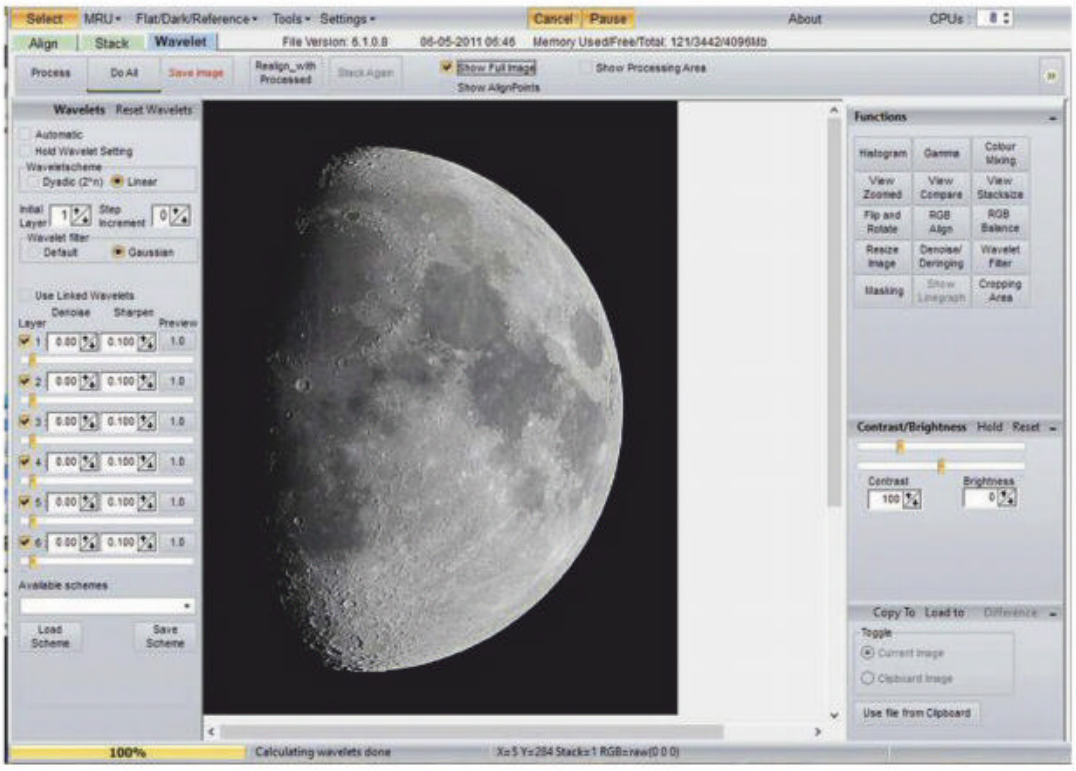
Imaging the Moon can be achieved with just a DSLR, lens and tripod. As you start out you'll be pleased with the details from a single frame, after making minor adjustments in Photoshop. For the best level of detail, however, you'll need to attach your camera to a scope with a T-ring and adaptor to give a longer focal length. For planetary imaging, the longer the focal length of your telescope, the better.

To get sharper lunar details you can stack multiple DSLR images, or you can use a planetary camera. With its high frame rate, a planetary camera will cut through atmospheric turbulence more effectively than a DLSR, but either is a good choice for the Moon. For planetary imaging however, a planetary camera is best for capturing detail, and you'll need a laptop to control it.

For either type of camera the best program to use for stacking your lunar or planetary images is AutoStakkert!. This freeware assesses which files to keep or discard from a stack. To stack, open the software, upload and select the 'Image Stabilization' option, either 'Surface' or 'Planet' (depending on whether the Moon is completely in the field of view). The 'Analyze' function will show graphically which frames provide the best data, and you can opt to stack a percentage accordingly.

Once stacked, the next piece of software you'll need for overhauling your lunar or planetary image is RegiStax. Its important setting is the 'Wavelets' function (see figure 4), as this sharpens and emphasises detail. Further tweaks can be made in Photoshop, by using the 'Brightness/Contrast' and 'Hue/Saturation' settings.

For lunar photography, many opt to make a mosaic, particularly if the telescope you've used allows detailed crater images (see figure 5). It's important to get the order of the software right if you're stitching frames together. First stack your images in AutoStakkert!, then upload them to ICE to create the mosaic, and upload the full mosaic image into RegiStax. This ensures that you sharpen each element within your mosaic evenly and stops the final mosaic looking 'patchy'.



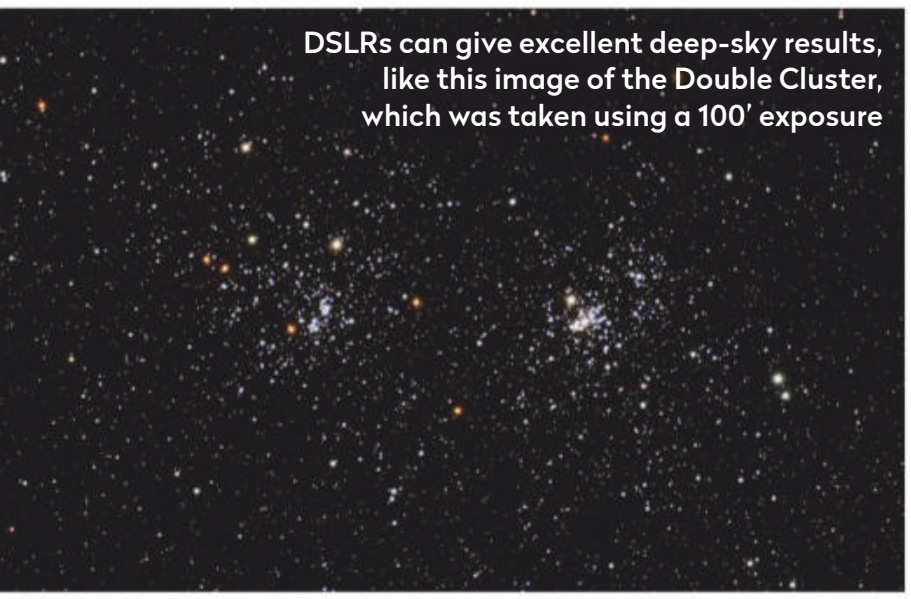
▲ Figure 4: once your lunar image has been stacked you can use the 'Wavelets' function in RegiStax to carefully emphasise surface detail

▲ Figure 5: you can create a stunning Moon mosaic, but make sure you use the software in the correct order

STEVE MARSH X 2, CHARLOTTE DANIELS X 4, BERNHARD GOTTHARDT/CCDGUIDE.COM

Deep-sky imaging

The most technical type of processing rests on how you capture your data



DSLRs can give excellent deep-sky results, like this image of the Double Cluster, which was taken using a 100' exposure

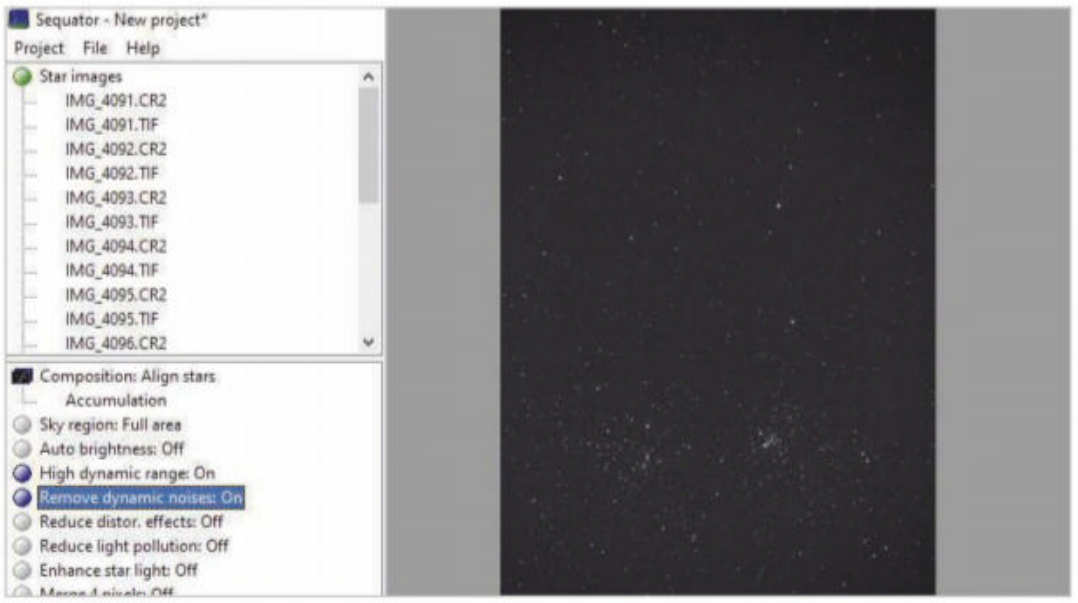
Summer means galaxy season, and even though the nights are lighter, it's still a good time to begin imaging deep-sky objects (DSOs) such as galaxies, star clusters and nebulae. While a long focal length camera lens is fine for some targets, a telescope is the best option; you will need a T-ring and adaptor to use one with a DSLR.

Although DSLRs are a popular choice and achieve excellent results, the long exposures needed for DSOs mean that many astrophotographers opt for cooled CMOS or CCD cameras. These come in either mono or one shot colour (OSC) varieties.

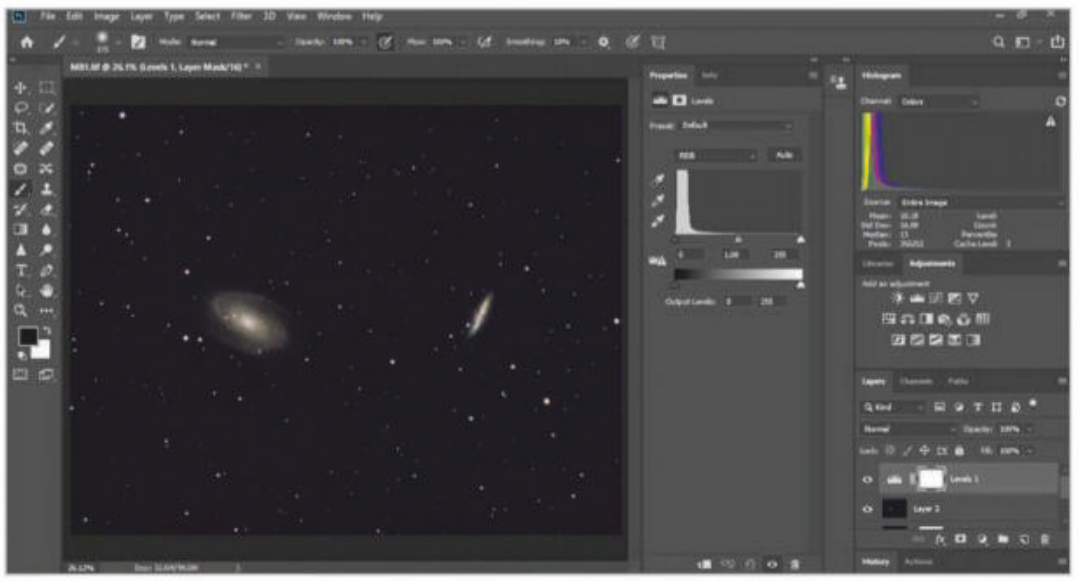
Calibration frames (darks, bias and flats) are an integral part of DSO processing. The trade-off from long exposures is the potential for noise and vignetting to affect images, which makes processing challenging. Dark and bias frames reduce noise, while flat frames remove any vignetting.

Two popular stacking programs for deep-sky imaging are Sequator and DeepSkyStacker (DSS). Both are simple to use, although DSS recognises bias calibration frames (whereas Sequator does not) and is more advanced. Sequator is perhaps the best stacking program to start with until you become more comfortable. Once star and calibration images are added we suggest switching on 'High dynamic range' and 'Remove dynamic noises' (see figure 6).

Once calibrated, DSO images can be enhanced in Photoshop (see figure 7). Settings we recommend include 'Levels' and 'Curves', 'Hide all' and 'Reveal all' masks, and the 'Median' and 'High Pass' filters. The masks help to adjust certain areas without affecting the whole image; these can then be blended using the 'Gaussian Blur' function. A 'Median' filter dims background stars and increases the impact of nebulae (find it under 'Filter > Noise'). Lastly, the 'High Pass' filter ('Filter > Other') allows you to bring out further details from your object. Once applied, set the Layers mode from 'Normal' to 'Soft light' to blend.



▲ **Figure 6: click Sequator's 'High dynamic range' and 'Remove dynamic noises'**



▲ **Figure 7: use Photoshop to bring out more details from your deep-sky target**

Processing software

Where to find the programs mentioned:

Adobe Photoshop – monthly subscription – **www.adobe.com/products/photoshop**

Adobe Lightroom – monthly subscription – **www.adobe.com/products/photoshop-lightroom.html**

AutoStakkert! – free – **www.autostakkert.com**

DeepSkyStacker – free – **http://deepskystacker.free.fr/english/index.html**

GIMP – free – **www.gimp.org**

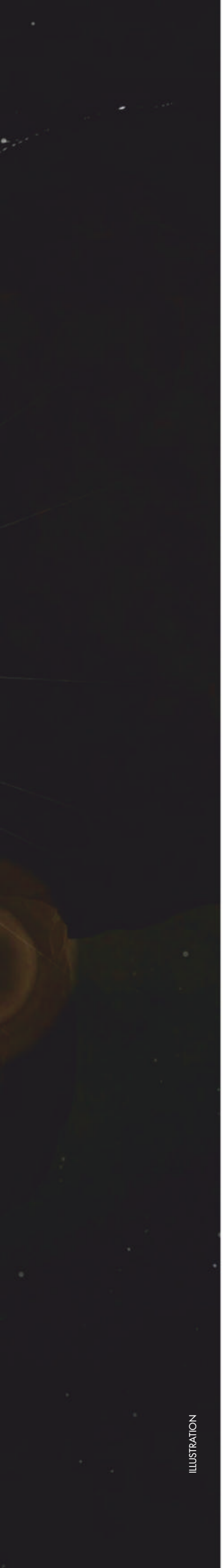
Image Composition Editor (ICE) – free – **www.microsoft.com/en-us/research/product/computational-photography-applications/image-composite-editor**

RegiStax – free – **https://www.astronomie.be/registax**

Sequator – free – **https://sites.google.com/site/sequatorglobal**

Startrails – free – **www.startrails.de**

Rock of ages: when New Horizons flew past the Kuiper Belt object (KBO) Arrokoth in 2019, it became the most remote object ever visited by a spacecraft



ILLUSTRATION

The edge of the SOLAR SYSTEM

Astronomers are revealing that there is far more to our cosmic neighbourhood than the planets alone, as **Ezzy Pearson** discovers

When most people describe the Solar System, they think only of the eight planets orbiting our Sun. Yet in truth, our neighbourhood goes far beyond that. Outside their orbits lies a vast and invisible expanse of space that astronomers are beginning to shine a light on.

Beyond Neptune lies a ring of icy objects left over from the formation of the Solar System, known as the Kuiper Belt. The region extends between 30 and 50 AU (where 1 AU is the distance between Earth and the Sun). Theorists first proposed its existence after the discovery of Pluto in 1930 led astronomers to wonder if other worlds might be hiding out there. It's only recently that technology has been able to reveal these icy objects en masse, and now telescopes such as PanSTARRS and the upcoming Vera Rubin Telescope scan the sky every night, looking for the distant specks of Kuiper Belt objects (KBOs) moving across the background stars.

Through the years there have been several targeted surveys taking a deep look at specific areas in the region. One of these looked for a potential target for one of the few spacecraft which has ventured into this mysterious space – New Horizons. The probe flew past Pluto on 14 July 2015, before passing by a second KBO, Arrokoth, on 1 January 2019. "We searched for a new target for four years beginning in 2011, culminating in 2014 with the discovery of Arrokoth by Hubble," says Alan Stern, the principal investigator of New Horizons. "We found dozens of Kuiper Belt objects, but only two were within our fuel reach. We're now starting a new search using large ground-based telescopes to find a third flyby target."

As well as getting close-up views of these distant worlds, New Horizons has also been using its Long range Reconnaissance Imager (LORRI) telescope to examine several neighbouring KBOs while travelling through the neighbourhood, giving a broader context to the detailed views from the flybys.

"These objects are too small to see in detail from any telescope on Earth or even the Hubble Space Telescope," says Stern. "With New Horizons we can determine their light curves, their rotational periods and their shape. We can search for satellites and improve our knowledge of how many KBOs have moons. In addition, we can study the microphysical properties of the surface, such as roughness. That can only be done from New Horizons."

To the Kuiper Belt and beyond

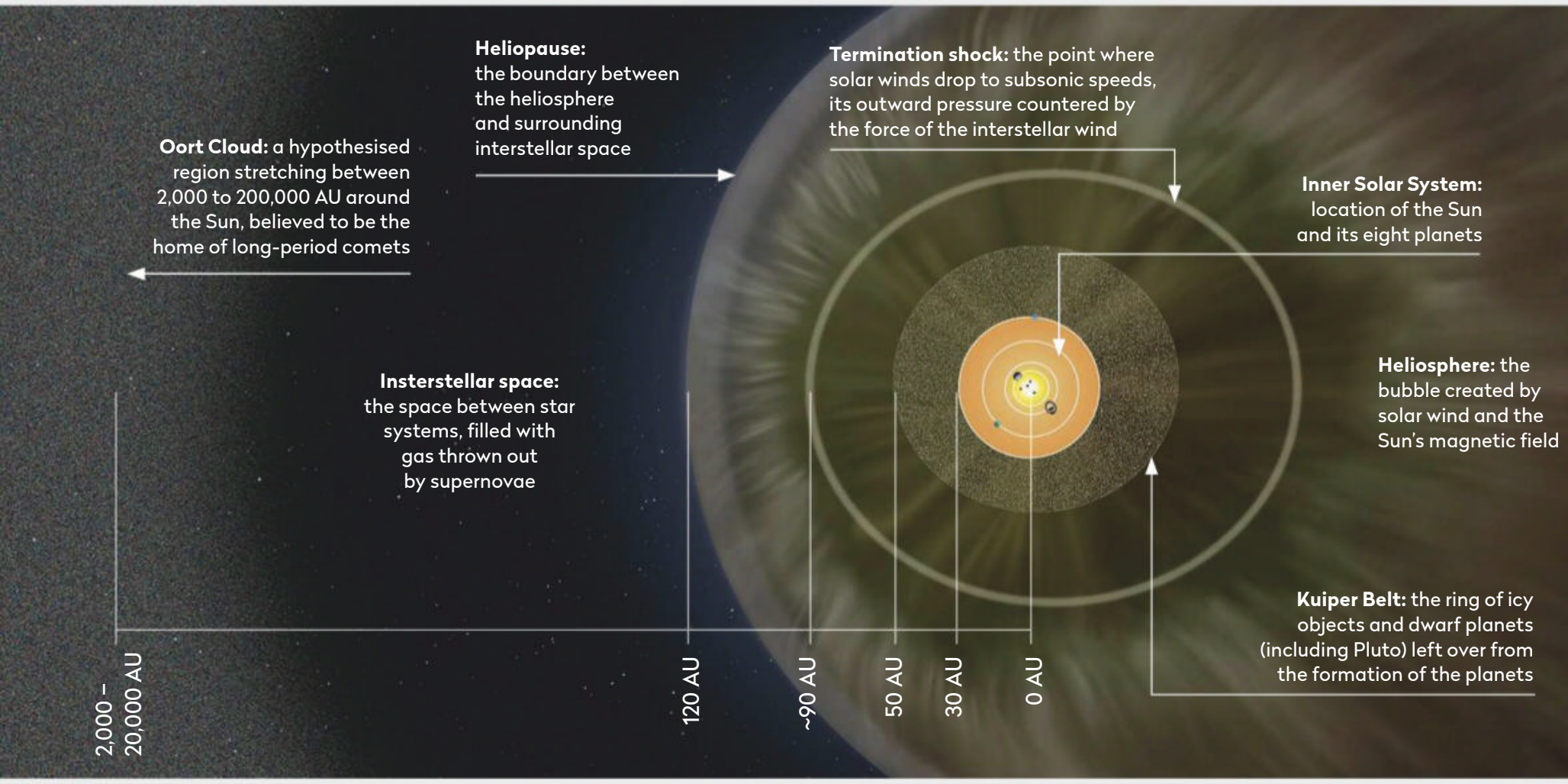
Throughout its journey through the Kuiper Belt, New Horizons has measured the distribution of dust in the seemingly empty space. Eventually astronomers expect the spacecraft will notice these dust levels falling away, signalling its time in the Belt is done. "The Kuiper Belt only runs a finite distance," says Stern. "By the late 2020s, around 2027, we will exit the Belt. It's not the end of the mission though. There's a lot of demand for New Horizons because we're far out in the Solar System carrying an amazing scientific payload."

Researchers are already requesting valuable time on the spacecraft to look at the heliosphere, the bubble of gas generated by the solar wind which surrounds our Solar System, kept in place by the Sun's magnetic field. Already, New Horizons has discovered pickup ions – particles which originate in interstellar space, but which are now trapped in the heliosphere. ►

MARK GARLICK/SCIENCE PHOTO LIBRARY/ALAMY STOCK PHOTO

On the outskirts of the Solar System

There's far more to our corner of the Galaxy than just the Sun and its planets



▲ **Leading the way: the two Voyager spacecraft are heading out towards the distant Oort Cloud, an extended region of icy objects**

ILLUSTRATION BY PAUL WOOTTON, OPHER/ET. AL

▸ New Horizons isn't the only spacecraft looking out for particles from the edge of our Solar System, however. Since 2008, the Earth-orbiting Interstellar Boundary Explorer (IBEX) has been imaging the outer reaches of the heliosphere where the magnetic field of the Sun meets up with the Milky Way's. It's examining energetic neutral atoms, particles which originated inside the heliosphere, but which have interacted with the galactic magnetic field and been scattered backwards. By mapping these neutral atoms, researchers can then extract details about the structure of the outer heliosphere.

"A big discovery was a structure called the IBEX Ribbon, a structure with two to three times more particles coming out of it," says David McComas, IBEX's principal investigator. "The Ribbon has got dimmer over time as the pressure of the solar wind changes."

IBEX has been operating long enough to watch the heliosphere throughout an entire 11-year solar cycle, observing the Ribbon dim and brighten as solar activity fluctuates. Astronomers are still pondering what creates the Ribbon, but it's thought to have something to do with the heliosphere's interaction with the interstellar magnetic field.

IBEX was only able to observe this strange structure as the spacecraft gives a global overview of the region. But what it cannot provide is detailed information about conditions at any one point. To take those measurements you need to be in situ. Four spacecraft have visited this region. Pioneer 10 and 11 lacked the power to take any readings, leaving only two explorers – the Voyagers.

As the Voyager probes speed ever further away from Earth they've been collecting data, allowing astronomers to construct a 3D map of the heliosphere, showing the various features as the probes pass through them.

Breaking free

Voyager 1 began its exit from the heliosphere back in 2004, when it passed through the termination shock, the point which marks the boundary of the Sun's magnetic field, where its influence begins to lose sway to the surrounding galactic magnetic field. "The termination shock is where the solar wind meets the interstellar medium and abruptly slows down," says Ed Stone, project scientist for the Voyager missions.

Like with the IBEX Ribbon, it's thought the termination shock is linked to the solar cycle, moving inward and outward with solar activity, so that when Voyager 1 passed through the termination shock in 2004 it was 94 AU from the Sun, yet when Voyager 2

Far from home: the Voyager spacecraft are currently journeying through the heliosphere in different directions

ILLUSTRATION

passed it three years later, it found the termination shock was only 84 AU out, suggesting the shape of the heliosphere was far more complicated than previously imagined.

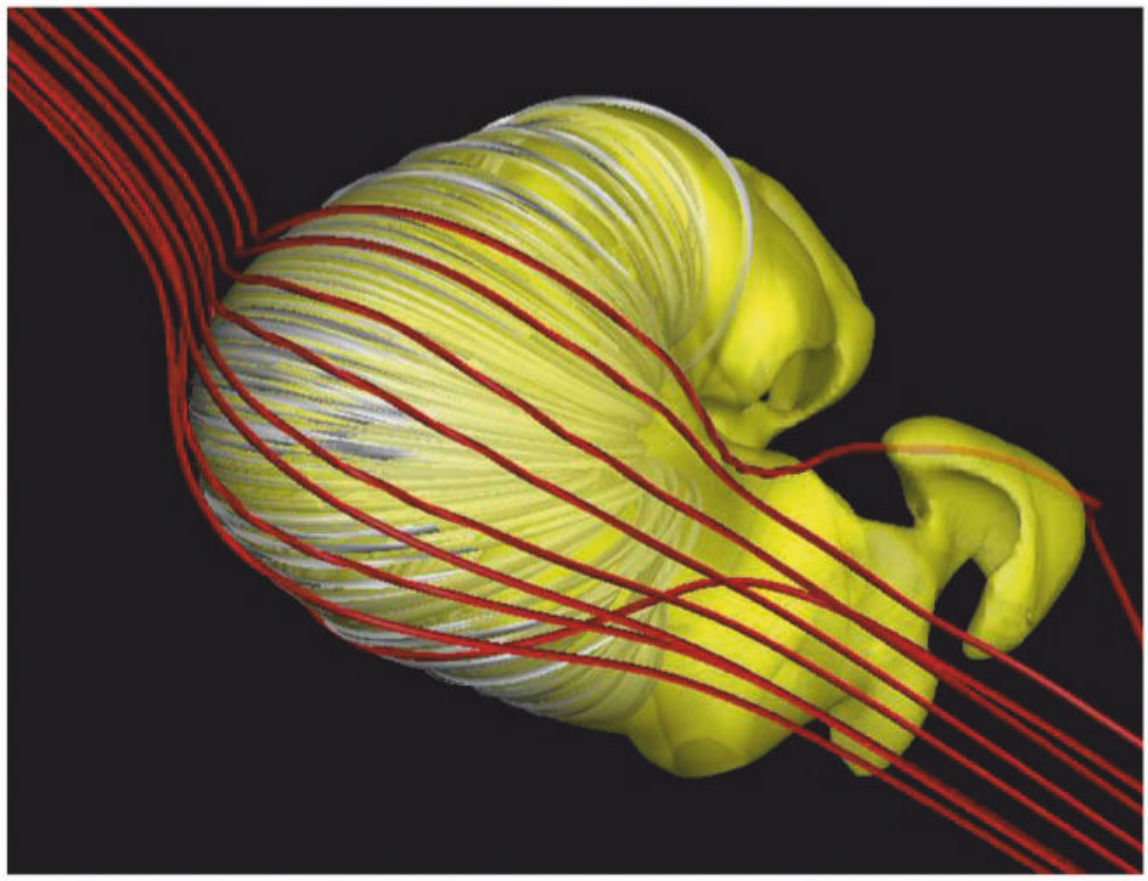
With the joint data of these two spacecraft, astronomers have found the space beyond the termination shock is filled with magnetic bubbles created by the Sun's field folding and twisting as it interacts with the Galactic field, before finally crossing the edge of the heliosphere, known as the heliopause – the point interstellar space begins.

The view of the Voyagers is limited – they are each seeing only one path through the region, albeit in different directions. "Voyager 1 is in the northern hemisphere of the heliosphere and Voyager 2 is in the south. Voyager 1 is heading out along the meridian – in other words into the interstellar wind – while Voyager 2 is off on the flank of the flow," says Stone.

Voyager 1 crossed the heliopause in 2012, while Voyager 2 did so in 2018, showing once again how the heliosphere changes throughout the solar cycle. "We believe Voyager 1 left the heliosphere when it was shrinking and the boundary was moving towards the Sun a little bit. When Voyager 2 left it was expanding," says Stone.

Comparing views

Both spacecraft are now journeying through the outermost region of our Solar System, where the magnetic field and particles from our Sun begin to meld in with those of the Milky Way. "Inside the heliosphere the magnetic field comes from the Sun, but outside it's from the Milky Way, so there's an abrupt transition and that's one of the things we're measuring," says Stone. "Voyager 2 also has a working plasma instrument which can tell us how the solar wind interacts with the interstellar medium."



▲ **Simulations using Voyager data suggest the heliosphere could have a complex, cresent-like shape**

Dr Ezzy Pearson is *BBC Sky at Night Magazine*'s news editor. She gained her PhD in extragalactic astronomy at Cardiff University

Already the pair have turned up some unexpected twists to the heliosphere's story, such as finding that the interstellar magnetic field is unexpectedly pointing in line with that of the solar magnetic field. However, this could just be a symptom of the fact that the two spacecraft are still in the turbulent region where the interstellar medium and the solar wind meet. Stone hopes the Voyagers' dwindling power supplies will last long enough to pass into calmer interstellar waters. "We won't get completely free, but we should see the interstellar magnetic field become smoother and more representative of the Milky Way," says Stone.

Even if they live to reach pristine interstellar space, it will be another 40,000 years or so before the Voyagers escape the Sun's gravitational influence and officially leave the Solar System. Before then, the spacecraft will travel through the Oort Cloud, a vast region 2,000 AU from the Sun where long period comets are believed to originate.

The Voyager team are trying to squeeze as much data out of the pair before they lose power, as they will be our last glimpses of the region for a long time. Though New Horizons is also sailing out towards the heliopause, it will almost certainly run out of power before reaching it.

There have been several new missions proposed which would explore the dim and distant region at the edge of the Sun's influence – from probes that will investigate the outer planets and Pluto, to spacecraft whose sole purpose is to look beyond the heliopause – but none are currently scheduled.

Even with our limited view of the Solar System's vast edge, it is evident that the region is not the empty, inert place it first may seem. Instead, it is a region of icy boulders, where speeding particles and turbulent magnetic fields connect our star with the expanse of interstellar space beyond.

The fundamentals of astronomy for beginners

EXPLAINER

The science of meteor showers

Earth's course through space dust produces a remarkable spectacle in the night sky

NITISH WAILA/ALAMY STOCK PHOTO, GERALD RHEMANN/CCDGUIDE.COM, S. DEIRIES/ESO

▲ Shooting sky: a spectacular panorama of the Milky Way reveals Lyrid meteors streaking through the sky above Hatu Peak in Shimla, India

Although seemingly empty, the space between the planets of our Solar System is teeming with vast numbers of meteoroids, small pieces of rock and dust largely originating from comets and asteroids but also, to a lesser extent, from the terrestrial planets and rocky satellites. A small number even originate from outside our Solar System: so-called interstellar dust. Meteors are produced when these particles enter Earth's atmosphere at extremely high speeds (ranging from around 11km to 72km per second) causing them to burn up and leave a bright momentary streak across the sky.

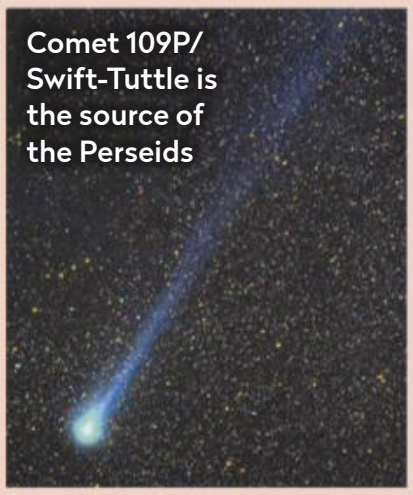
Earth encounters approximately 40,000 tonnes of extraterrestrial dust every year. Although this may sound like a lot, on a typical night it means you might see just a few meteors an hour streaking randomly across the sky. These are called sporadic meteors. At certain times of the year these numbers can increase to around 100 meteors an hour in events called meteor showers, as Earth ploughs through denser streams of particles on its orbit around the Sun.

Of all meteor showers that occur today, one of the oldest known is the Lyrids; observational records for it date back to 687 BC. In these ancient times, meteor showers were interpreted as portents and then later as phenomena of the upper atmosphere. Their extraterrestrial nature was not realised until the idea of an Earth-centred Universe lost favour and astronomers became intrigued with meteors. This was spurred on by the occurrence of spectacular meteor showers in the 19th and 20th centuries, as well as the findings from studies of meteorites – fragments of larger meteors that survive atmospheric entry and reach Earth's surface.

We now know that the debris streams which produce meteors are left behind by comets during their passage through the inner Solar System. The ice that binds the rocky and dusty constituents of comets is heated by the Sun and turns to vapour, flowing

THE PERSEIDS

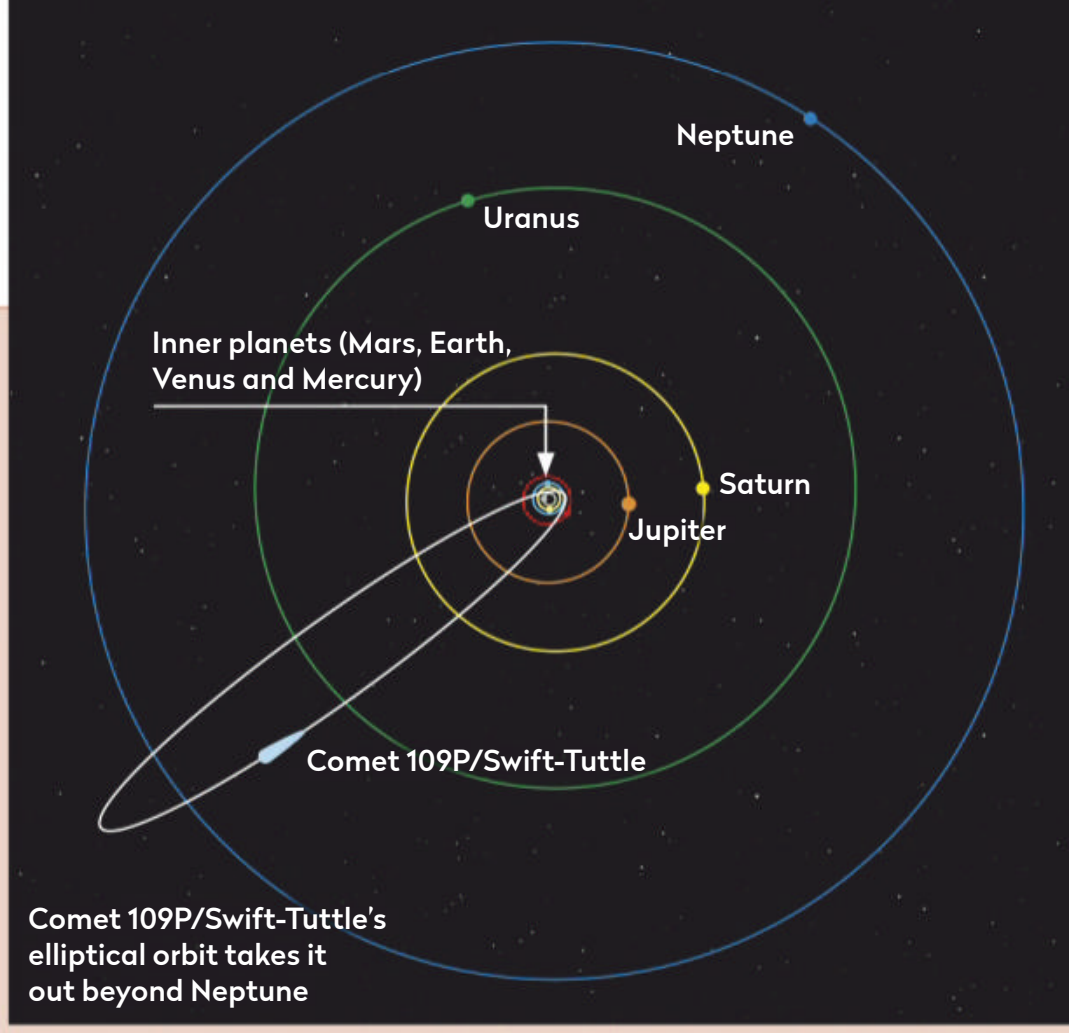
Look out for one of the best meteor showers in the annual calendar, which peaks every August



Comet 109P/ Swift-Tuttle is the source of the Perseids

The Perseid meteor shower, with its radiant point in the constellation of Perseus, makes a great starting point for those interested in viewing meteors. Soaring through Earth's atmosphere at about 60km per second, the showers start in mid-July and peak in intensity around 12 August (see page 42 for more details). The best time to observe will be after midnight. As with all meteor showers, we see more meteors after midnight when we are on the side of Earth facing forward along its motion around the Sun, meaning we run into more meteoroids.

It's estimated that the total mass of material contained within the Perseid stream is somewhere upwards of 10 billion tonnes. Comet 109P/Swift-Tuttle is the parent of the Perseids and has an orbital period of about 133 years.



Comet 109P/Swift-Tuttle's elliptical orbit takes it out beyond Neptune

Its last trip through the inner Solar System was in the early 1990s, generating increased shower intensity in 1991, 1992 and 1993. In fact, during the 1993 Perseid meteor shower, a meteoroid is believed to have impacted the OLYMPUS satellite, starting a chain of events that ultimately led to its demise, while onboard Mir, cosmonauts reported hearing pings believed to have been meteoroids impacting the station's hull.

▲ **Seeding meteors: Comet McNaught's dramatic 2007 dust tail, an example of the debris streams that produce meteor showers**

outwards from the nucleus and carrying these grains with it. These grains create a trail of particles that follows approximately the orbit of the parent comet.

Points of view

While Earth's orbit around the Sun is roughly circular, comets whose paths cross the inner Solar System have orbits that are typically highly elliptical and inclined to the ecliptic. This means the paths of Earth and cometary debris can, albeit rarely, intersect. In such cases, a meteor shower will be observed annually when Earth reaches this point in its orbit. As Earth hits these trails, meteors viewed from the surface appear to radiate from specific points in the sky. These meteor showers are given names relating to the constellations that are nearest these radiant points. The Leonid meteor shower, for example, appears to originate from the constellation of Leo.

Type the name of any meteor shower into an internet search engine and you'll find details of when to see it and what the theoretical peak number of meteors per hour will be. These predictions of meteor shower timings and intensities are generated by using a combination of past observational data from radar and optical telescopes and computer modelling. Observations provide details of the activity profile (how the number of meteors changes as Earth barrels through the stream), while computer models allow us to simulate and study the release and subsequent movement of particles from particular comets.

Meteor showers are observed annually, and some have been recorded for millennia, but for how long will they continue? The answer is entwined in the fate of the parent comet. Ultimately, the meteor shower will begin to diminish when the comet is no longer able to top up the debris stream. The comet could disintegrate, it could be gravitationally perturbed by a planet into another orbit, or even simply become dormant after losing all of its volatile ices. So, while well-known and well-loved meteor showers like this month's Perseids exist, take the time to step outside, look up and try to catch sight of a few.

▶ For more details about the Perseid meteor shower see pages 26, 42 and 68

Dr Penny Wozniakiewicz is a planetary scientist and space dust expert based at at the University of Kent

Practical astronomy projects for every level of expertise

DIY ASTRONOMY

CAUTION
Never observe or image the Sun with the naked eye or any unfiltered optical instrument

Create a smartphone spectrograph

Construct a home-built instrument to view and record visual spectrums

◄ **The completed spectrograph can be used to reveal the bands of colour from a fluorescent tube (inset)**

More **ONLINE**

Download templates and additional photos for this project. See page 5 for details.

This month we revisit a classic project for demonstrating the nature of light – a spectrograph, which can be used visually and with a smartphone or a hand-held camera. We have provided plans and extra photos to help, along with key dimensions, but because your phone and tube size may vary, you might need to adapt these to suit.

To use the spectrograph, simply point the front towards the bright object you are studying. When you look into the back you'll see that the light from the source is spread out into a rainbow-like spectrum. Bright coloured bands or dark gaps in an otherwise continuous spectrum can reveal a lot about the nature of the source. If you mount your smartphone or hold up a camera you can record any spectrum for more analysis.

This spectrograph has three key elements, a tube (stiff cardboard with a lid and a base), a slit and a grating. The slit is formed by two razor blades, taped across a hole in the base of the tube so that they are almost touching; remember to handle them carefully. The grating is made from a small piece of a blank CDR (recordable compact disc), with its label removed, mounted across a similar hole in the lid of the tube. This is cut from an area close to the circumference of the disc where its microscopic lines are almost straight.

Incoming light passes though the slit, forming a narrow beam. When this passes through the grating, it is divided, forming tiny copies of the beam. The light from each of these interacts, like the ripples from many pebbles dropped into a pool; sometimes the waves add together so the light is visible, sometimes they subtract so it's not. The result is that the constituent wavelengths (colours) of the source light are observed at varying angles away from the original beam.

Mark Parrish is a bespoke designer. See more of his work at: **buttondesign.co.uk**

Bands of colour

We calculated that with a standard CDR the violet end of the spectrum is deviated by 14˚ and the red end by 28˚, so our phone platform (and grating) can be adjusted to meet the beam at about 21˚ off axis, centralising the resulting image of the spectrum. If you aim your spectrograph at a fluorescent tube or an LED, you will see an emission spectrum of distinct bands of colour (pictured left). These correspond to chemical elements which are excited and giving off photons of light.

When we recorded the Sun's spectrum, we were able to observe Fraunhofer lines – narrow, dark bands in the continuous 'rainbow' (an absorption spectrum), caused when elements in the Sun's outer layer absorb certain wavelengths of white light emitted from within. It's also possible to use software to calibrate your spectrograph and measure the wavelengths of the spectrums you image. We experimented with spectral-workbench, a free online resource found at **www.publiclab.org**.

We hope you enjoy making and using your first spectrograph and, if you want to take things further, there is a thriving community of amateur observers doing spectroscopy that you can tap into.

What you'll need

▶ Marking out tools (ruler, compasses and pencil), coping saw, drill and range of bits, tin snips, screwdriver and glue gun.

▶ A small quantity of 6mm plywood or equivalent (approximately A4 size), a sturdy tube with a lid and base and a strip of thin wood for the phone surround.

▶ Sundries include a blank CDR disc; a small hinge and screws, M4 x 25 screws with wingnuts and washers; a small amount of stiff card; dark tape or craft foam for masking stray light and a rubber band.

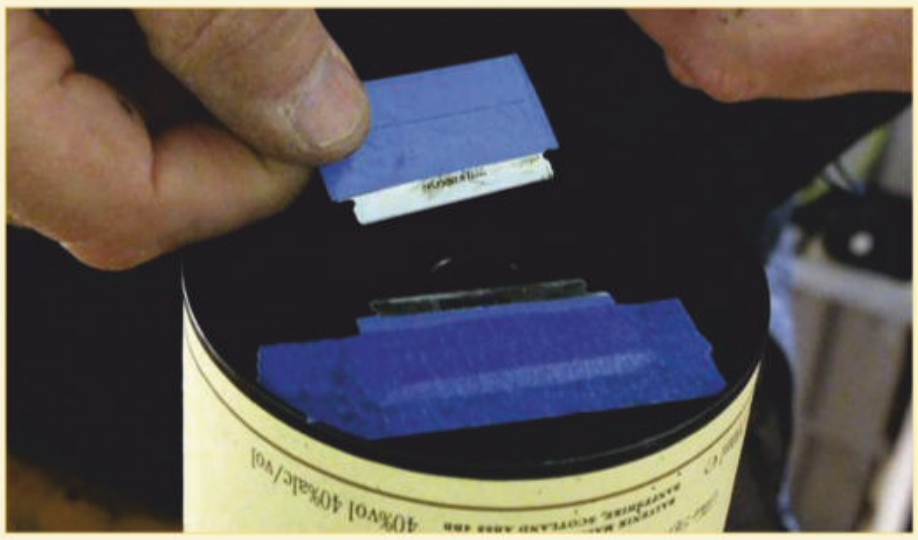
▶ For the finish you'll need some matt black spray paint for the interior of the tube, plus saw dust and paint suitable for the other parts.

ALL PICTURES: MARK PARRISH

Step by step

Step 1

After carefully drilling holes (approximately 18mm diameter) in the base and lid, paint the inside of the tube with matt black spray. We shook some sawdust around inside when the paint was wet and then repainted it to make it really non-reflective.



Step 2

Taking care, form the slit by taping two fresh razor blades across the hole in the base. We taped up one side of each blade first to minimise the risk of injury while we experimented with the gap where wider equals brighter, narrower equals finer definition.

Step 3

Cut a small section from the CDR and then peel off the foil label by applying, then removing, sticky tape. Cut a holder (with a 12mm hole) from some card. This will be taped to the underside of the phone platform, so the grating covers the smartphone camera lens.

Step 4

Stick a plywood disc, with a central hole, to the lid. Use a small hinge to join it to the phone platform. Cut a curved slot in the side section and glue an M4 screw (with washer and wingnut) into the edge of the phone platform so you can set the angle.

Step 5

After positioning the phone on the platform so the camera lines up with the grating, make some 'walls' from strips of wood. We made a small notch in the side of a long wall so we could hold the phone in place with an elastic band.

Step 6

Before the final paint job, test the spectrograph to make sure the platform angle is set right and the slit and grating are aligned. When you are happy, glue up and use craft foam and tape to mask any gaps and prevent stray sources of light.

Take the perfect astrophoto with our step-by-step guide

ASTROPHOTOGRAPHY CAPTURE

Can you catch the perfect Perseid?

A manual camera with a considered focal length will work wonders for your meteor-hunting

ALL PICTURES: PETE LAWRENCE

August means that the peak season for meteors is upon us, including the Perseids. In fact, there are many meteor showers active from the end of July into August, and their activity overlaps. As a result, if skies are clear and dark, there's a good chance of seeing a meteor at this time of year.

Two additional factors make August meteor-hunting pleasurable. For starters it's a relatively warm month; it can get chilly at night and the evenings are a bit damp, but overall the conditions are far more comfortable than they are for spotting the Geminids in December.

The next factor is the night's length. While it takes stamina to stay up from dusk to dawn in mid-winter, a full night watch at the start to middle of August is just a few hours long, making it possible to get some sleep.

Photographing meteors isn't hard, but the tricky bit is having your camera pointing in the correct direction with the shutter open as a bright trail appears. Being able to optimise the probability of this happening is the key skill in meteor photography.

▲ Trail finders: the short and warm nights of mid August are ideal conditions for hunting the Perseids

Pete Lawrence is an expert astro imager and a presenter on *The Sky at Night*

A manual camera works best for meteors, something like a DSLR or a mirrorless or a bridge camera. A wide lens works best but there are limitations to weigh up. Your chances of capturing a trail increase with sky coverage, so a fisheye lens covering the entire sky might sound like a good bet, but unfortunately most trails will be puny and difficult to see. As you increase focal length the field of view narrows, reducing the probability of capturing a trail because some will occur outside the frame area. But, if you are lucky and capture a trail using a longer focal length lens, it will invariably have more presence than a fisheye would deliver.

Striking a balance

The balance between area covered and meteor trail appearance is reached around the 14–20mm mark, although this isn't written in stone. A fast lens is also preferable to a slow one. Setting the lens fully open allows the maximum light in, but can also introduce distortions in star shapes towards the edge of field.

A common mistake for deep-sky imagers attempting meteor trails is to set the sensitivity high, look at a test result on the back of the camera and reject the ISO setting because the image quality looks poor. This is because deep-sky images benefit from mid to low ISO values to maintain tonal quality and keep noise to a manageable level. But meteor trails don't last long, typically less than a second, and to capture them the deep-sky imaging philosophy needs to be put on hold and the camera ISO ramped up for high sensitivity.

Use our tips (opposite) and see what results you get back. Meteor photography is like celestial fishing, you never know what you're going to catch!

Recommended equipment: DSLR or mirrorless camera with a lens of focal length 14–20mm

▸ *See pages 26, 42 and 64 for more on the Perseids*

✉ Send your images to:
gallery@skyatnightmagazine.com

Step by step

STEP 1

Choose your lens: a 14–20mm focal length is ideal, and the fastest possible is recommended. Lens speed is measured by the lowest value the focal ratio (f-number) can be set to. An f/2 setting will do better under low light than one of f/3.5. You could have one camera for wide-fields, and one at a longer focal length for narrower views.

STEP 2

You don't necessarily need a tracking mount for meteor imaging. A sturdy tripod will be adequate. If you do choose a tracking mount, make sure it's not going to rotate the camera into a position where part of the sky is obscured later on. Aim the camera at an altitude 60° above the horizon, with the centreline of the long frame axis pointing back towards the shower radiant.

STEP 3

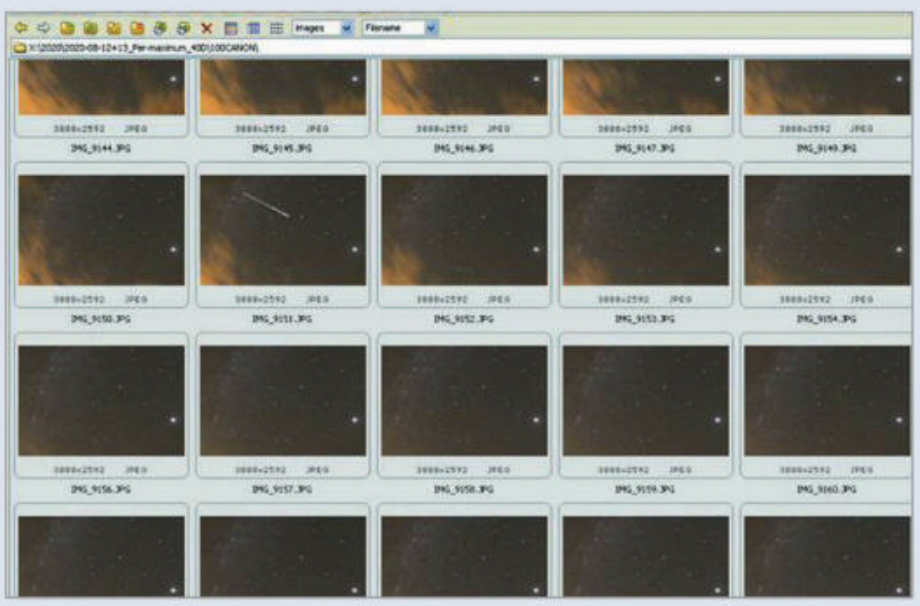
Set the camera to manual or bulb, and the lens to manual focus. Adjust the f/number to its lowest, but close by a stop of two if the stars are distorted. Set a mid- to high-ISO and choose an exposure length; try 30" to begin. You can work the camera automatically with continuous shooting and a lockable remote shutter release.

STEP 4

Have plenty of spare charged batteries to hand for your camera, or obtain a mains adaptor. Dew is also a problem on meteor watches; various heater band solutions are available, or an online search will reveal ways to make your own. Carry out regular lens checks, armed with a 12V hairdryer to clear any moisture.

STEP 5

Pre-focus the lens at infinity; using the Live View function on a bright object such as Jupiter is one way to achieve this. Jupiter's Galilean moons make good focus targets. Take a test shot and examine it. If it's too dark, consider upping the ISO setting. If too bright, lower the ISO or shorten the exposure, but not below 10".



STEP 6

This part of the process requires patience. Set the camera going, sit back and enjoy the visual view. Next, download the images and go through them looking for meteor trails. A program such as Faststone View, **bit.ly/3hbfkXk**, is good for this. If you find a trail, rename it by adding a 'meteor_' prefix to the name.

Expert processing tips to enhance your astrophotos

ASTROPHOTOGRAPHY PROCESSING

Create a stunning ‘Mineral Moon’ image

Process your images to bring out the subtle, colourful textures of the lunar surface

ALL PICTURES: DAVE EAGLE

▲ **Mineral marvel: the final Moon image reveals the contrasting colours of brown (iron) and blue (titanium) on the lunar surface**

The Moon looks more or less colourless through a telescope. Even the Apollo astronauts observing it up close, described it as mainly grey, or slightly brown. But the Moon’s surface material, known as regolith, does have very subtle colour differences, which are dictated by the mineral composition in any particular area. This mineral distribution on the lunar surface was mapped in great detail by the US Clementine probe in 1994, but the good news is that you can produce images showing these colours without having to launch a spacecraft to do so. It’s easily achieved and all you need is a one shot colour (OSC) camera and a telephoto lens or telescope, plus a bit of image-processing knowhow.

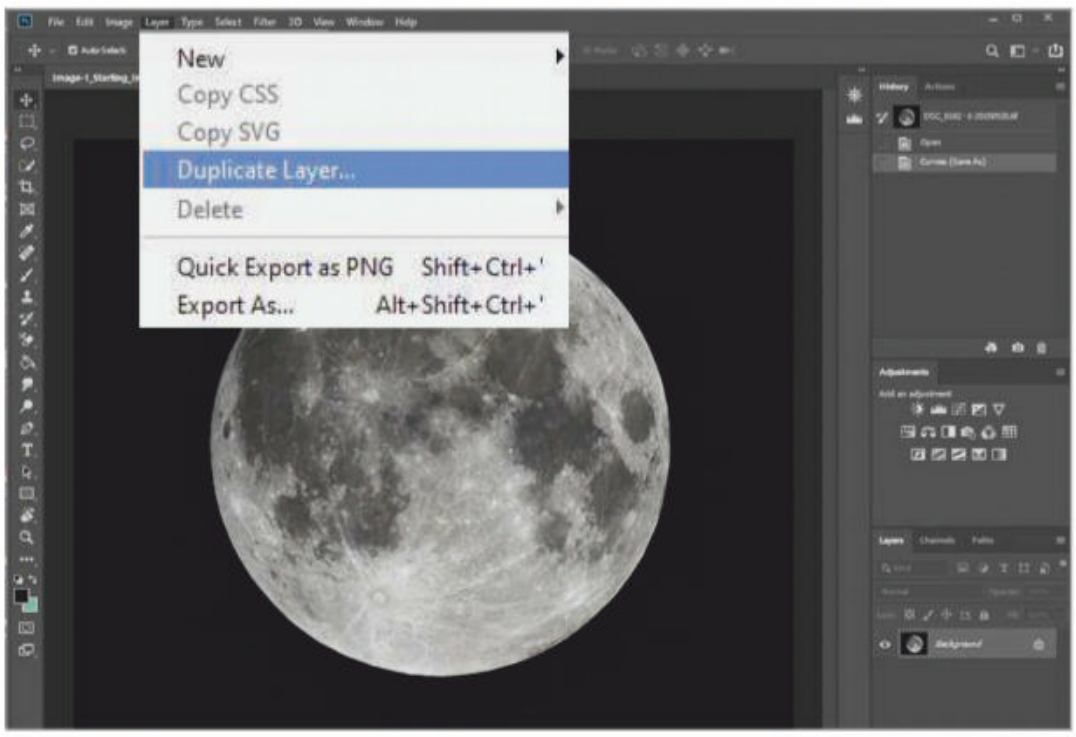
As with most image processing, the success of the technique relies on having a decent image at the start. The best image for creating a mineral Moon will be evenly exposed, such as the one shown here taken with a DSLR (see top image, opposite page). Keeping the exposure as short as possible helps to keep the image sharp; the settings used here were ISO 100 with an exposure of 1/640”. Most DSLRs come with a preview mode that flashes to show areas of overexposed pixels, which is invaluable in helping you set the camera to an exposure that doesn’t overexpose. If you have been taking photos of the Moon for a while you will probably already have many lunar images at different phases that would benefit from this technique.

Getting started

To begin, open your image in Photoshop. This would preferably be a RAW image or, depending on your Photoshop version, it may be better to convert it to TIFF format first. Images in JPEG format can be used, but JPEGs compress the data so the image quality will suffer, plus it won’t be as detailed. The first step is to create a ‘Luminosity Layer’. This will enable you to make some changes to the colour and hold back any adverse artefacts that could quickly manifest themselves as a result. A ‘Luminosity Layer’ locks the value of the pixels in the image, up to a point, so that the brightness of any pixel in the resulting image does not change too much as adjustments are made.

From the ‘Menu’ select ‘Layer > Duplicate Layer’ (see Screenshot 1, right). Name the new layer ‘Luminosity Layer’ and click ‘OK’. From the ‘Menu’ make sure that ‘Window > Layers’ is ticked to reveal the ‘Layers Window’. This ‘Layers’ menu should now be visible on the right-hand side of Photoshop. Click on ‘Layers’ to reveal the two layers in the image, before clicking on the newly created upper ‘Luminosity Layer’ so it’s selected. From the drop-down menu just above the layers, which shows the default ‘Normal’ setting, select ‘Luminosity’ at the bottom of the list (See Screenshot 2).

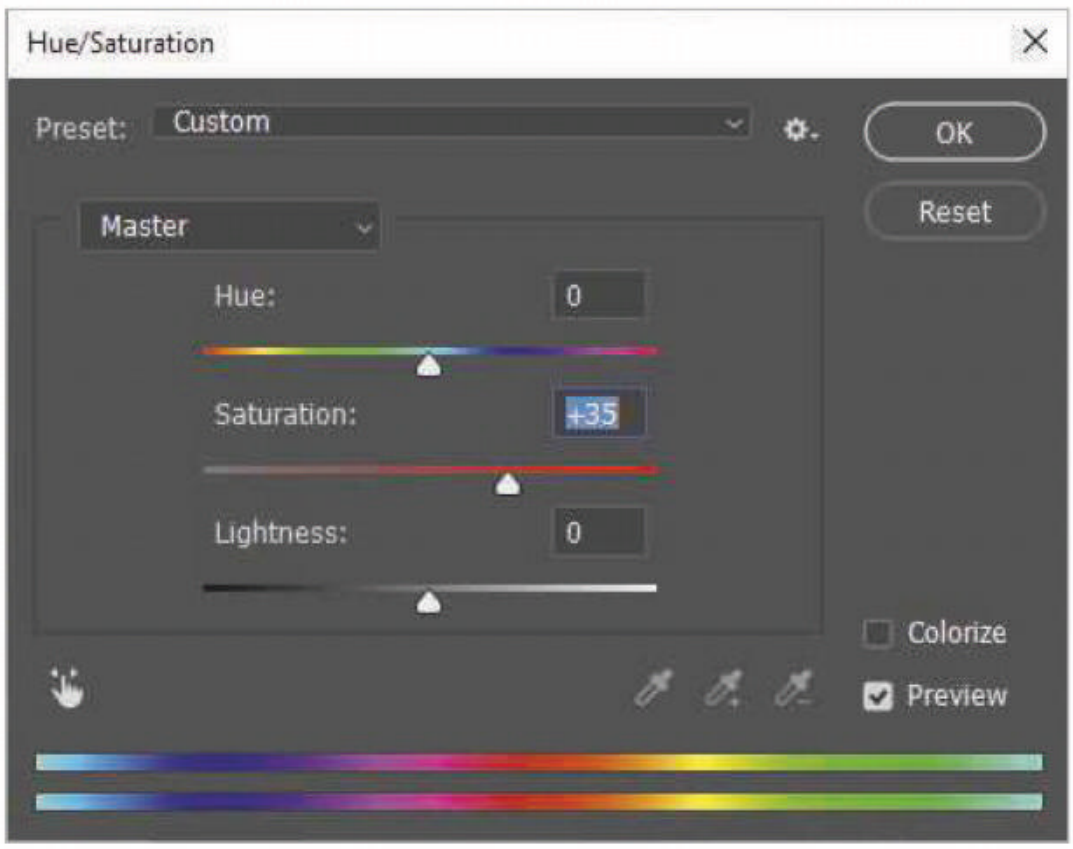
Your starting image should be a well-exposed lunar image



▲ **Screenshot 1: to create your duplicate layer, select 'Layer > Duplicate Layer' and rename it 'Luminosity Layer'**

◄ **Screenshot 2: In the Layer's palette click on 'set the blending mode for the layer' and in the drop-down change 'Normal' to 'Luminosity'**

▼ **Screenshot 3: increase saturation, making sure the lower layer is still selected from the menu**



3 QUICK TIPS

1. Get the sharpest image possible; use the mirror-up function to reduce camera vibrations.

2. Do not oversaturate an image as this will create colours that don't exist.

3. If bright spots in the image show coloured fringes, apply a soft Gaussian blur to the saturated lower layer.

Adjustments now need to be made to the saturation of the lower layer. Depending on your camera, the colour balance may need to be changed as an OSC camera usually has a green bias due to the built-in Bayer matrix that produces the colours. Click on the lower layer to select it and from the menu click 'Image > Auto Color', or press 'Shift+Ctrl+B'. Not much change will be noticed at this stage, but the Red, Green and Blue colour channels have now been balanced in the lower layer image. Next you need to increase the saturation; making sure the lower layer is still selected from the 'Menu', go to 'Image > Adjustments > Hue/Saturation'. Adjust the 'Saturation' slider to somewhere between +30% and +40%, but no more than this, and then click 'OK' (See Screenshot 3).

You may already see some colour appearing, but not much at this stage. So, repeat this saturation increase step a number of times. Remember that it always gives better results if this is done in a series of smaller more subtle steps, rather than fewer more drastic increases. It's very easy to overdo it so stop when you reach the colour you like. Once completed, flatten the image and save it with a different file name. This ensures that you do not overwrite your original starting image. In our final completed image (on the opposite page) you'll notice that brown iron-rich areas can be seen, while titanium-rich areas within Mare Tranquillitatis appear bluer.

Dave Eagle is an astronomer, astrophotographer, planetarium operator and writer

Your best photos submitted to the magazine this month

ASTROPHOTOGRAPHY GALLERY

More **ONLINE**
A gallery containing these and more of your images

△ Leo Triplet

PHOTO OF THE MONTH

Mukund Raguram, Lake Sonoma, California, 21 March 2020

Mukund says: "Galaxy season can sometimes feel challenging for imagers with smaller refractors, but the Leo Triplet – NGC 3628 (top), M66 (left) and M65 (right) – looks good at any focal length. I drove to the darkest skies in my region to shoot this target and was pleased to pick up NGC 3628's very faint tidal tail. The seeing was excellent and I'm happy with the level of detail in each galaxy."

Equipment: ZWO ASI 1600MM camera, Explore Scientific ED127 apo refractor, EQ6-R Pro mount **Exposure:** 160 x 90" L, 25 x 120" RGB **Software:** NINA, PixInsight

Mukund's top tips: "I saw the biggest improvement in my imaging when I started to consider pixel size and matching my image scale to my region's average seeing conditions. At 1.17 arcseconds per pixel, my resolution is not limited by my seeing on most nights and I'm able to get sharper, cleaner subframes. I also recommend considering an off-axis guider for mid to long focal lengths and spending time getting a good calibration in PHD2 guiding software. Better guiding has made a remarkable difference to my images. Also, remember that without good processing skills, all the equipment in the world won't help. I recommend really learning PixInsight. It's expensive and complex, but worth the time."

△ Star trails

Jamie Cooper, Northamptonshire, 15 May 2020

Jamie says: "I pass over this bridge regularly and one day it occurred to me that this stretch of the M1 runs north to south. This provided the opportunity to incorporate the stars' apparent rotation around Polaris as Earth spins on its axis, along with the movement of people on our planet. It shows Earth and humanity all in motion."

Equipment: Canon 5D Mk III DSLR, 8mm Samyang lens, Manfrotto tripod **Exposure:** ISO 160; Stars: 2h 45'; Traffic: 6' **Software:** Startrails, Photoshop

◁ Phases of Venus

Rich Addis, Wallasey, Merseyside, February to May 2020

Rich says: "I've been capturing Venus every couple of weeks since February. Not only is it fascinating to see how the light changes as the planet moves around the Sun, but it's also amazing to see how much larger it becomes as it approaches Earth in its orbit."

Equipment: ZWO ASI 120MC colour camera, Celestron NexStar 6SE Schmidt-Cassegrain **Exposure:** Composite of 6 x 5,000 frame videos with an exposure time of 1ms **Software:** FireCapture, AutoStakkert!, Photoshop

◁ Crescent Nebula

André van der Hoeven, Hendrik-Ido-Ambacht, Netherlands, 2016–19

André says: "I like this image because of the beautiful Crescent Nebula, but even more because of the 'hidden' Soap Bubble – a very faint nebula like a cosmic pebble hidden in plain sight. It's amazing this was only discovered in 2008 and how it's now possible to image it with equipment that is in reach of the average astrophotographer."

Equipment: QSI 583ws mono camera, TMB 92SS apo refractor, Sky-Watcher NEQ6 mount **Exposure:** 40h, 115 x 900" Ha, 32 x 1200" OIII **Software:** Astro Pixel Processor, PixInsight, Photoshop

◁ Moon

Ronald Brecher, Guelph, Ontario, 31 May 2020

Ronald says: "The Moon was just past first quarter, showing nice shadow details with accentuated small features. My setup is optimised for deep-sky rather than lunar imaging, but this came out well. Can you see the 'Lady in the Moon'? She's like Wilma Flintstone's mother in profile, looking left."

Equipment: QHY 16200A camera, Optolong Ha filter, Sky-Watcher Esprit 150ED apo triplet refractor, Paramount MX mount **Exposure:** 25 x 0.010" **Software:** PixInsight

▽ Omega Nebula

Anas Albounni, Razeen desert, Abu Dhabi, UAE, June 2018 and August 2019

Anas says: "I had been imaging in the deserts of the UAE, but with the COVID-19 lockdown I realised that finishing this data set wasn't going to happen anytime soon. This is where good processing comes in handy."

Equipment: Starlight Xpress Trius SX 694 mono CCD camera, Sky-Watcher Esprit 100 ED triplet apo refractor, Sky-Watcher AZ-EQ6 mount **Exposure:** 16 x 600" Ha, 16 x 600" O **Software:** PixInsight, Photoshop

C/2020 F8 (SWAN) ▷

José J Chambó, Siding Spring, New South Wales, Australia, 27 April 2020

José says: "This is Comet SWAN, taken during morning twilight in Australian skies. At that time it was shining at mag. +6.5 and was observable through binoculars. Its tail was at least 4° long, extending beyond this wide-field image."

Equipment: SBIG STL-11000M camera, Takahashi FSQ-106ED astrograph, Paramount ME mount **Exposure:** 1 x 600" L, 1 x 120" RGB **Software:** PixInsight

△ Jellyfish Nebula

Karl McCluskey, Castleford, West Yorkshire, 17 January 2020

Karl says: "This is the first time I've ever imaged the Jellyfish Nebula. I had to wait for it to clear the tall trees from my light-polluted back yard. I'm very happy with the image for only four hours of integration time."

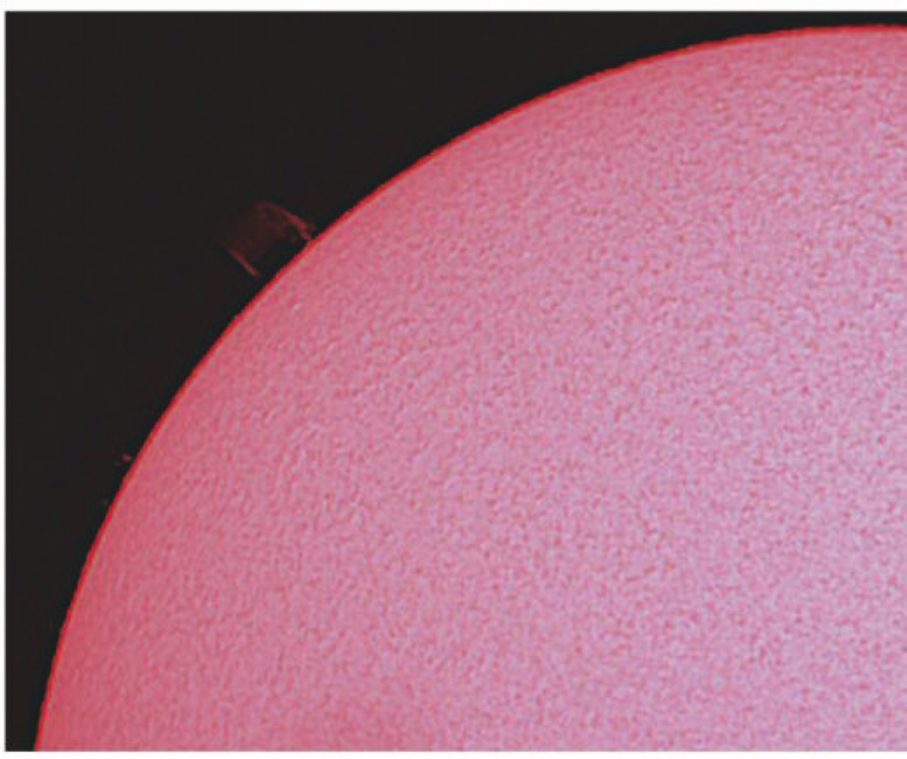
Equipment: Altair Hypercam 183M Pro Tec camera, William Optics GT71 apo triplet refractor, Celestron AVX mount **Exposure:** 12 x 600" Ha, 12 x 600" OIII **Software:** SharpCap Pro, Astro Pixel, Lightroom

▽ Sun

Sue Silver, Sheffield, South Yorkshire, 2 June 2020

Sue says: "I love observing the Sun and I started imaging it fairly recently – this is my best picture so far. The Sun has been at solar minimum for some time now, but just recently there has been quite a lot more activity; mostly prominences and not much surface detail as yet. This is one of biggest prominences I have seen in quite a while, with a smaller one just below."

Equipment: ZWO ASI 120MC-S colour camera, Lunt LS60T H-alpha B600 telescope, Sky-Watcher EQ5 Pro Go-To mount **Exposure:** 30" AVI video **Software:** SharpCap, AutoStakkert!, GIMP



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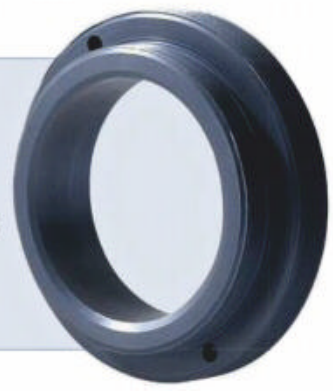
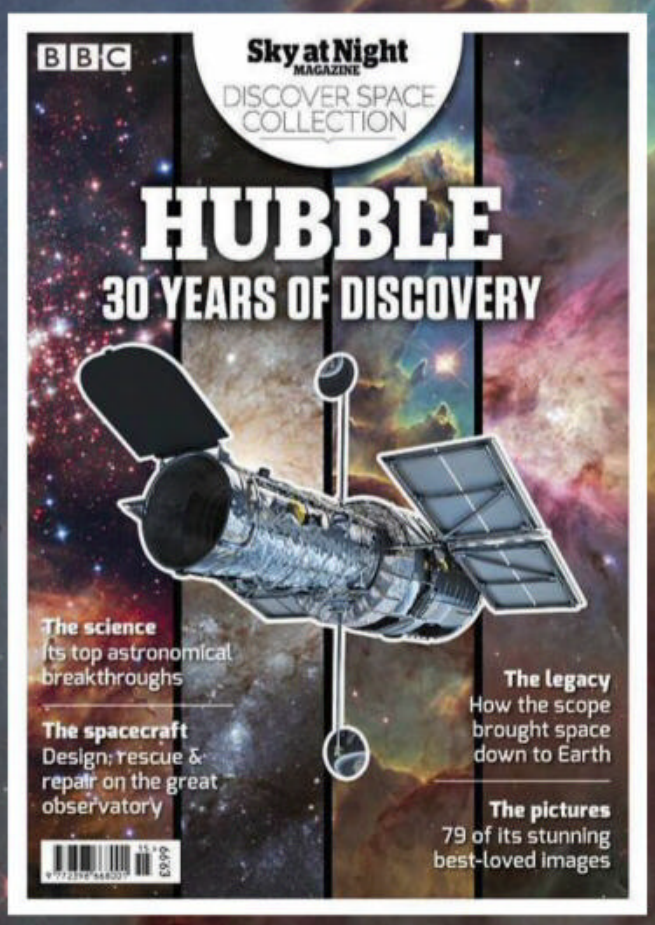
Whether you're a seasoned astro-photographer or a beginner, we'd love to see your images. Email them to contactus@skyatnightmagazine.com. Ts&Cs: www.immediate.co.uk/terms-and-conditions

We've teamed up with Modern Astronomy to offer the winner of next month's Gallery a finder–guider adaptor, which connects T-thread guide cameras from ZWO, Orion and others to 9 x 50 standard finders from Sky-Watcher. The accessory comes with full instructions and support. www.modernastronomy.com • 020 8763 9953



SPECIAL EDITION



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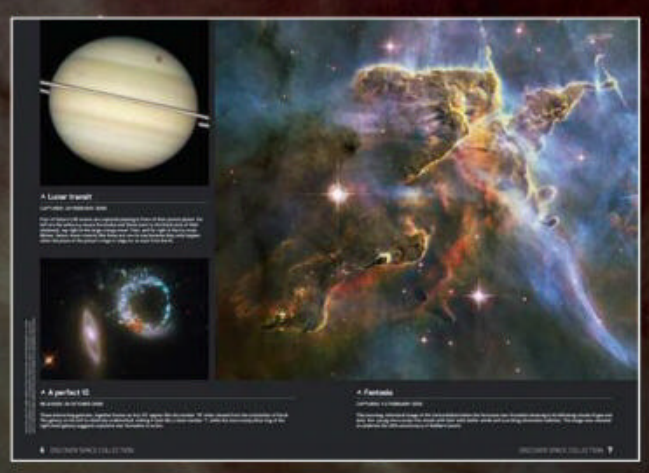

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The best in equipment, accessories and books each month

REVIEWS

Find out more about how we test equipment at
www.skyatnightmagazine.com/scoring-categories

82

With a full set of accessories and a superior sensor, the Deep Sky Astro Camera 7.1MP will speed up your astro imaging

HOW WE RATE

Each product we review is rated for performance in five categories. Here's what the ratings mean:

★★★★★ Outstanding ★★★★★ Very good
★★★★★ Good ★★★★★ Average ★★★★★ Poor/avoid

PLUS: Books on the end of the Universe and our fascination with Mars, plus a roundup of the latest astronomy gear

@THESHED/PHOTOSTUDIO

FIRST LIGHT

RVO Horizon 72ED refractor

An impressively lightweight telescope that fits the bill for visual observing and imaging

WORDS: PAUL MONEY

VITAL STATS

- **Price** £599
- **Aperture** 72mm
- **Focal length** 432mm; f/6
- **Optical design** Fully multi-coated ED doublet lens in collimatable cell
- **Mounting** Tube rings with 30cm Vixen dovetail bar
- **Focuser** 10:1 dual speed microfocuser; 87mm of travel
- **Weight** 2.68kg (OTA)
- **Extras** Retractable dew shield; 2- to 1.25-inch adaptor; front and back dust caps
- **Supplier** RVO
- **Tel** 0190 977 4521
- **www.**rothervalleyoptics.co.uk

Short focus refractors have definitely made their mark, becoming very popular in recent years, and the new RVO Horizon 72ED is set to join them. The improved performance of such refractors makes them easy to use, quick and simple to mount and ideal for transporting to find better skies, whether it's for foreign travel or to a nearby dark-sky site. Although far-off travel has been difficult in recent times, this had little impact on our tests because we had the refractor during one of the longest periods of clear skies we can remember.

The Horizon 72ED, produced by Rotherham-based Rother Valley Optics, has a 72mm objective doublet lens with a focal length of 432mm, giving a focal ratio of f/6. The doublet is composed of FPL-53 glass, an extra-low dispersion glass that gives the telescope the 'ED' in its name. This helps to correct the slight spread in the wavelengths of light which produces chromatic aberration, or colour fringing, a defect often found in such short focus refractors when they aren't properly corrected. The scope and tube rings come in the RVO colours, a stylish white tube with a sky-blue visual back and orange detailing. The orange tube rings are attached to the extra-long Vixen-style mounting bar with small risers, which prevent the focus lock screw catching on the bar.

Deep-sky viewing

The basic package consists of the telescope with a visual back that accepts 2- and 1.25-inch eyepieces and accessories, the latter size accommodated by a 2- to 1.25-inch adaptor in black. Also included is a finderscope shoe and a smaller top Vixen bar, which allows you to mount additional accessories. Adding a mount of your choice, along with a star diagonal and eyepieces will create a wide-field setup, ideal for taking a visual tour of the Milky Way star fields, or viewing large clusters such as the Coma Star Cluster (Collinder 256) or the Pleiades and the Double Cluster in Perseus. The 72ED is also sold in a £947 imaging package aimed at deep-sky astrophotographers, which includes a 1.0x rotatable field flattener and a finder/guidescope.

Although the Pleiades wasn't visible when we had the Horizon 72ED, we enjoyed the rest of our selected targets visually. In our tests with a 26mm 2-inch eyepiece, at a magnification of 16x, we found the view to be pin sharp out to 80 per cent of the frame. It trailed off slightly towards the edges, but this is expected with such a fast focal ratio. The colour correction was spot on and, even when we pushed the magnification, we found our views of Albireo – with its gold and sky-blue components – were superb. ▸

Travel light

The lightweight, compact design of the RVO Horizon 72ED is impressive. In its stowed collapsed form, with the dew shield and focuser fully retracted, it is only 34cm long. The optical tube itself weighs just 2.68kg, light enough to hold easily in your hand and easy to remove from the tube rings to adjust position if needed.

These aspects enabled us to use the scope on our Star Adventurer tracking mount, the extra long Vixen mounting bar enabling us to achieve the best balance. We were then able to take a visual tour of many celestial targets manually without Go-To, with our dielectric star diagonal and a range of eyepieces in the focuser. We swapped to a GPCAM 290C camera and used a 5x Powermate to capture a video of the triple star Iota Cassiopeiae using the same simple setup. Only the COVID-19 lockdown stopped us taking the Horizon 72ED to a darker site and enjoying the easy setup without the need for a large mount.

ALL PHOTOS: @THESHED/PHOTOSTUDIO

Tube rings

The two tube rings give a firm grip but can be loosened to rotate the tube if needed. They have mounting holes on top for attaching additional equipment such as a guidescope, while below, they sit on a 30cm-long Vixen dovetail bar for attachment to a mount.

Visual back and finder shoe

The visual back comprises a blue 2-inch adaptor with three grub screws that ensure a tight fit to the tube. Three thumb screws hold 2-inch-sized eyepieces and accessories in place. There's also a black 1.25-inch adaptor to accommodate eyepieces of that size.

Focuser

A rack and pinion type with a 10:1 microfocuser for precise focusing, it has a generous 87mm of travel and a tension adjustment screw underneath. This allows for heavy equipment to be attached and locked, so the focus doesn't slip during imaging.

Optics

The objective lens is 72mm in diameter with a focal length of 432mm, giving a focal ratio of f/6 – suitable for visual or imaging purposes. A doublet lens made from FPL-53 glass, it is fully multi-coated for good control of colour correction and is mounted in a collimatable cell.

FIRST LIGHT

KIT TO ADD

1. RVO Horizon 1.0x rotatable field flattener

2. RVO Horizon 50mm finder/ guidescope kit

3. RVO M48 T mount (for Nikon SLR or Canon EOS)

▸ Encouraged, we swapped to a trusty 1.25-inch 26mm eyepiece and added our 5x Powermate to push the magnification to 83x, before aiming at the triple star Iota Cassiopeiae, which was low in the northern sky. We could easily see the further, fainter companion but the closer, brighter component only flickered into view. Increasing the power again we swapped in our 9mm eyepiece to give a magnification of 240x and brought all three components into view.

Grand tour

Dropping back to the 26mm eyepiece, and occasionally the 9mm ocular, we took a deep-sky tour. We can report pleasing views of our targets – including galaxies M81 and M82, the Double Cluster, M52, M11, M39, M17, the Coma Star Cluster, and the Dumbbell and Ring Nebulae.

Now it was time to attach a camera and begin imaging. We wanted to see how the basic telescope performed first, so we used our modified Canon 300 DSLR on the North America Nebula. Framing it so that the Pelican Nebula was also included, we took 78, 60 second exposures at ISO 1600 and stacked them with 10 dark frames using Astro Pixel Processor. We were thrilled with the result, but there was some coma towards the edges, which is to be expected with the fast focal ratio of f/6. RVO's 1.0x rotatable field flattener, which is extra (see Kit to Add), will correct this optical abberation. For our next test we tried the scope and camera with the loaned field flattener, taking 119, 60 second exposures of the nebulosity surrounding Sadr in Cygnus, at ISO 1600. The result was again pleasing, with pin sharp stars at the edges. It backed up our overall impression, that the Horizon 72ED is a cracking instrument for both wide-field observing and imaging.

Hard case

The tough, quality aluminium case has a cut-out interior for the telescope. It is lockable and has the RVO Horizon logo emblazoned on the lid. Its handle snaps into place to stop it flopping about, while the case itself is quite lightweight.

VERDICT

Build & design	★★★★½
Ease of use	★★★★★
Features	★★★★½
Imaging quality	★★★★½
Optics	★★★★½
OVERALL	★★★★½

▲ Nebulosity near Sadr, as imaged by the Horizon 72ED and a Canon 300D, with a stack of 119 x 60" exposures at ISO 1600

▲ North America and Pelican Nebulae, also taken using a Canon 300D, with a stack of 78 x 60" exposures at ISO 1600

@THESHED/PHOTOSTUDIO, PAUL MONEY X 2

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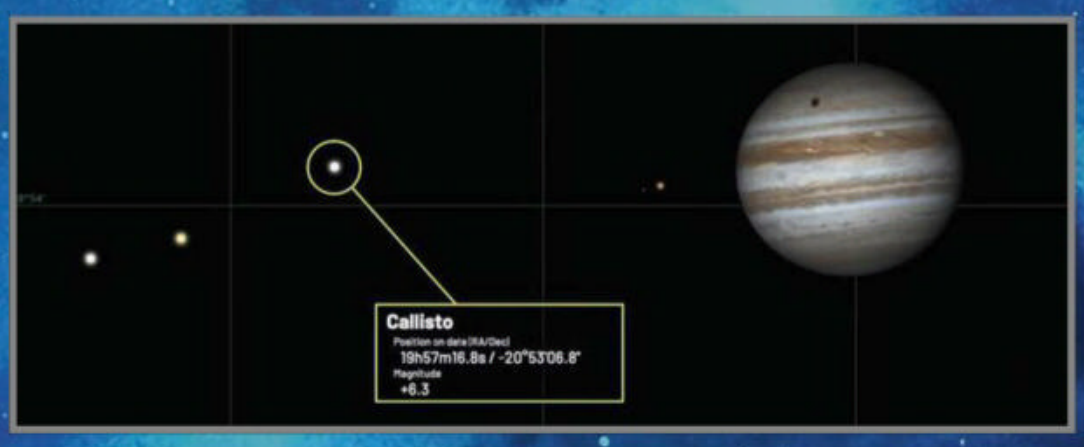

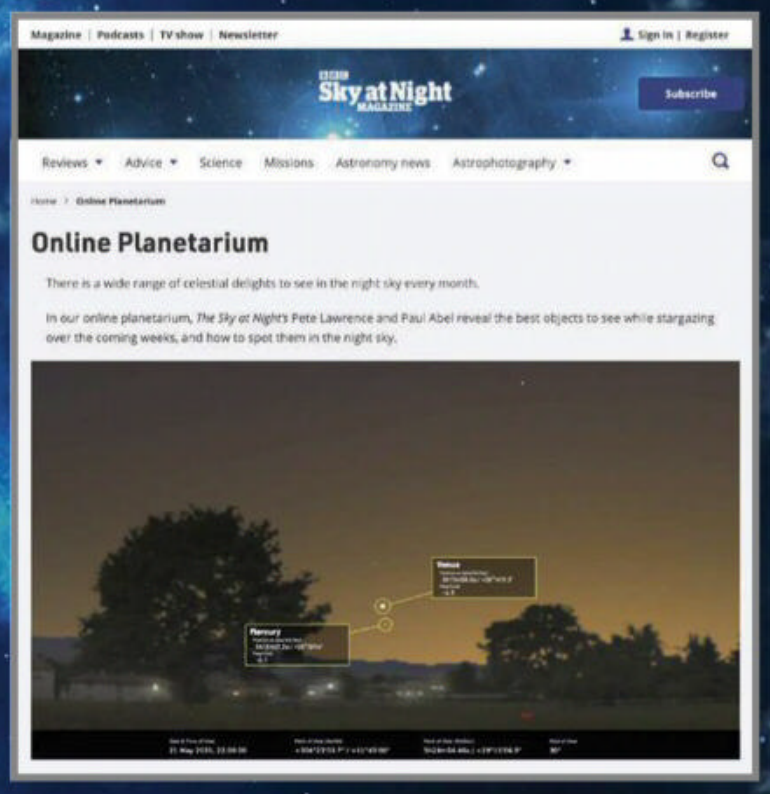

Staying up to date with each month's top sights has never been easier thanks to *BBC Sky at Night Magazine's* Online Planetarium. Each month, *The Sky at Night* presenter Pete Lawrence and Paul Abel, Director of the British Astronomical Association's Mercury and Venus Section, host a video tour of the night sky.

As annotated visuals show you where and when to look, they discuss which stars, planets, galaxies and nebulae should be the targets of your observations, as well as particular nights when features on the Moon are best on view in its monthly cycle of phases.

Their expert, lighthearted and entertaining commentary covers what equipment is best suited to each target, famous moments from the history of amateur astronomy, and insider hints and tips from personal experience gathered over many years of observing the starry skies. With a new instalment every month of the year, make *BBC Sky at Night Magazine's* Online Planetarium one of your bookmarks today!

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Length of Online Planetarium videos: 15-20 minutes. Online Planetarium visuals provided by kind permission of Stellarium.

FIRST LIGHT

Explore Scientific
Deep Sky Astro Camera 7.1MP

A high-resolution camera that enables high-speed captures of targets near and far

WORDS: GARY PALMER

VITAL STATS

- **Price** £2,099
- **Sensor** Sony Exmor IMX428 CMOS colour sensor
- **Sensor size** 14.4mm x 9.9mm
- **Resolution** 3,200 x 2,200 pixels
- **Megapixels** 7.1MP
- **Size** 80mm (diameter), 102mm (length)
- **Weight** 0.53kg
- **Extras** T2 thread to 2-inch telescope adaptor; USB 3.0 connection cable (150cm); power supply; dust cap; hard case; instruction manual; software CD
- **Supplier** Telescope House
- **Tel** 01342 837098
- **www.**telescopehouse.com

Explore Scientific has been manufacturing telescopes, mounts and eyepieces for a good while and now it has launched a range of cooled one shot colour (OSC) CMOS cameras aimed at deep-sky astrophotography. Here we take a look at the Deep Sky Astro 7.1MP, which uses an impressive Sony Exmor IMX428 CMOS colour sensor.

The camera is supplied in a tough black plastic case, along with all the accessories that you'll need to get started, including a software disc to install all the drivers and software. With a nice solid feel, the Deep Sky Astro 7.1MP camera is made from lightweight aluminium anodised in blue. On its back you'll find the main USB 3.0 socket and a USB 2.0 hub for additional connectivity. There is also a bank of small LED lights and a 12V power socket to attach the included power supply, which is used for the camera's TEC (thermoelectric) cooling system. Taking off the front cap reveals the Sony Exmor IMX428 CMOS colour sensor, which has a back focus of 17.5mm from the front of the camera.

Setting up the camera is easy once the software is installed, although we did note that the Explore Capture program is contained on a CD and would be better on a flash drive. That said, it's an extensive piece of software that offers lots of controls and settings. If, like many imagers, you prefer to use your own capture software, there is also an ASCOM driver included for doing so.

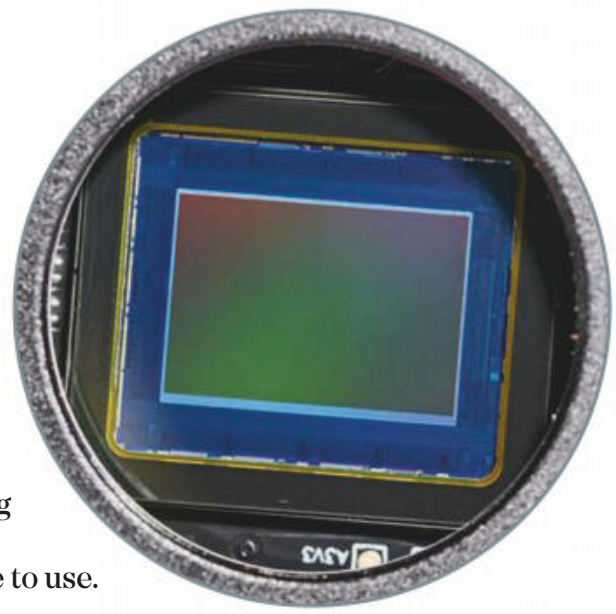
To begin, we attached the camera to a 115mm Starwave refractor and aimed at the Great Globular Cluster, M13, setting the camera at 60-second exposures with captures to run for an hour. We noticed two issues as the images started to roll in; the first was a glitch in the ASCOM driver causing the colour to be wrong, and the second was a lot of amp glow – an unwanted glow effect in the images that can indicate a possible problem with the camera itself. The next day we contacted Explore Scientific to run through the issues and the company responded quickly with updated drivers that corrected the colour and reduced the amp glow.

At the ready

On the next clear night, we went back to M13 and repeated the capture of 30, 60-second exposures and set about processing the images. There was a marked improvement in the result, with little or no amp glow in the images after processing. To understand why this is important, for the calibration frames to work, any dark frames must be captured at the same exposure and temperature as the light ▸

Speedy delivery

The camera houses a very low noise Sony Exmor IMX428 CMOS 7.1MP colour sensor with a resolution of 3,200 x 2,200 pixels and a size of 14.4mm x 9.9mm. This type of sensor is very sensitive to faint targets and allows you to capture deep-sky objects in a shorter amount of time. The pixel size of 4.5µm x 4.5µm makes the camera more suitable for telescopes with a short to medium focal length. Having a full range of 'region of interest' features, with a respectable frame rate in these modes, makes the sensor suitable for lunar and planetary imaging too. For easy control when deep-sky imaging it's equipped with a global shutter, with 1 x 1 and 2 x 2 bin modes. Having a relatively large field of view makes the framing of objects easy and this is also helpful for fitting in bigger deep-sky targets with larger aperture telescopes. Overall, the speed that you can capture objects is what makes this sensor a pleasure to use.



ALL PICTURES: @THESHED/PHOTOSTUDIO

USB 3.0 socket

The main computer connection is via a USB 3.0 socket, which allows high-speed captures when imaging objects such as the Moon and planets.

USB hub

Built into the rear of the camera is a two-port USB 2.0 hub, enabling connections to other equipment, such as a filter wheel, electric focuser or guide camera, without the need for lots of tangled cables running back to a computer.

Sensor window

The camera's optical window is AR-coated (anti-reflective) to cut down on reflections in captures. There is also an ultraviolet/infrared coating to reduce unwanted signals and improve star shapes. Without this, images taken with one shot colour (OSC) cameras can produce stars that look quite bloated.

Cooling system

The camera's temperature can be set up to 40°C below ambient with the built-in, two-stage thermoelectric cooling (TEC) system. Easy to set in most capture programs, it allows you to capture dark frames at any time and keep the same temperature as for the lights.

FIRST LIGHT

Accessories

A tough, foam-lined plastic case keeps the camera safe and a power supply runs its TEC cooling system. There is also a 2-inch nosepiece for connecting the camera to a scope, plus a software disc containing the Explore Capture program and ASCOM drivers.

KIT TO ADD

1. Explore Scientific ED apo 102MM f/7 FCD-100 CF HEX refractor

2. Explore Scientific EXOS-2 PMC-Eight Go-To mount

3. Explore Scientific 2-inch CLS nebula filter

▸ frames. If there is any difference then amp glow will remain in the images.

With all the clear nights we had we moved on to the spiral galaxies M51 and M81, capturing 60, 60-second exposures using the ASCOM driver to control the camera. As the images came in, we could see the sensor is very capable at capturing targets in a short amount of time. We set the gain to its minimum setting of 100 under ASCOM through the capture run and found that, even in a single exposure of 60 seconds, objects were bright and the stars were sharp. The processed images showed very little noise or unwanted artefacts in the background and, considering the short amount of exposure time, there was plenty of detail. Examining the stars, we noted that we could have reduced the imaging time to around 30 seconds and doubled the amount of exposures; this would have helped to retain star colour and cut down overexposure on brighter targets.

With the Moon shinning bright we switched the camera into Planetary mode and set about capturing some images in Video Capture mode. In Live Capture mode the camera shows quite a lot of green colour, but once the images are processed and colour-balanced there is a lot of detail to be seen.

It would be nice to see some extras included with other cameras in this price range, like a heated sensor window, and the amp glow reduced some more. This would give some more flexibility in the way the camera is used on single-shot astrophotography. However, all in all we were impressed with the images captured and the results obtained with the Deep Sky Astro Camera 7.1MP.

The Moon, captured with the Deep Sky Astro Camera 7.1MP and an APM 107 SED refractor, and processed in AS2 and Photoshop

▲ **Above left: M13, captured with a stack of 30 x 60" exposures by the Deep Sky Astro Camera 7.1MP and a Starwave 115mm refractor, and processed in PixInsight and Photoshop. Above right: the Deep Astro Camera 7.1MP's image of M51; 60 x 60" exposures taken with the same setup and processing**

VERDICT

Build & design	★★★★☆
Connectivity	★★★★★
Ease of use	★★★★★
Features	★★★★☆
Imaging quality	★★★★½
OVERALL	★★★★☆

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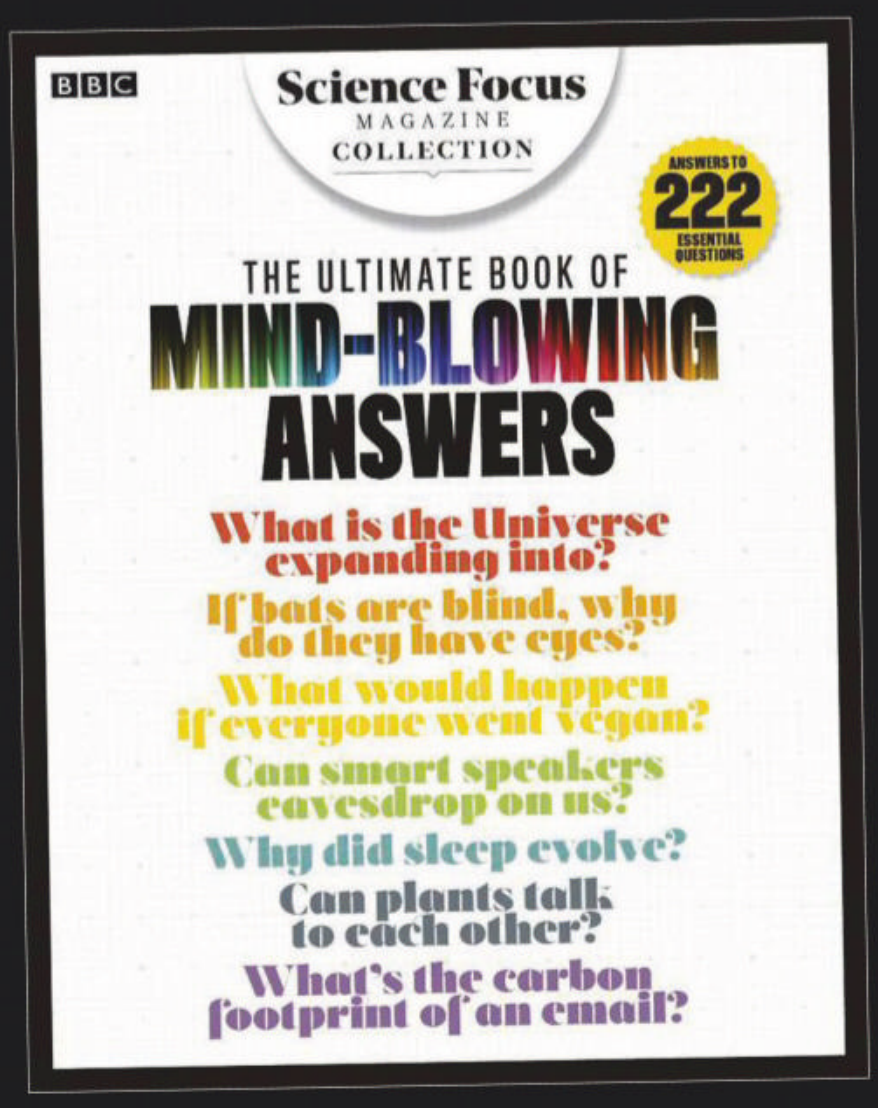
ANSWERS TO 222 ESSENTIAL QUESTIONS



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BOOKS

The End of Everything (Astrophysically Speaking)

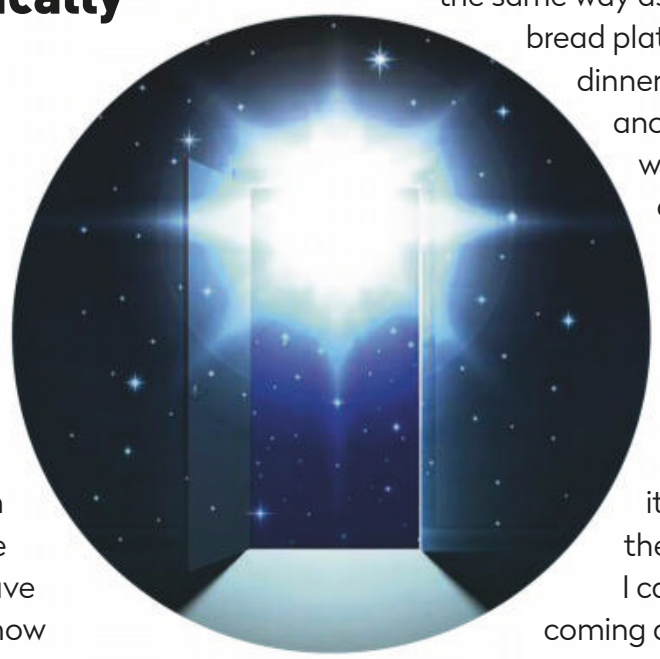
Katie Mack
Allen Lane
£20 ● HB

Cosmology has allowed us to piece together the history of our Universe and explain how we got to where we are today. But have you ever wondered how it will end? *The End of Everything* explores five possible scenarios for its ultimate demise: the 'big crunch', 'heat death', the 'big rip', 'vacuum decay' and the 'ekpyrotic scenario'.

The author seamlessly weaves her way through the essential physics you'll need to understand each Universe-ending possibility. Don't worry if you haven't heard of, say, the ekpyrotic scenario because Mack gives us a readily graspable explanation of this and many other concepts. Given the compact size of the book, she does, however, have to assume the reader is comfortable with some basics such as what a neutron star is, but it's still an accessible read for a keen beginner.

The book takes a look at how current and proposed future astronomical and particle facilities (such as CERN's Large Hadron Collider and Future Circular Collider, gravitational wave detector LIGO and the upcoming James Webb and Euclid Space Telescopes) may shed light on which path the Universe is going down. Given the subject matter, *The End of Everything* has the potential to be rather bleak, but Mack's humour keeps things light and humorous from beginning to end.

I loved the slight tangents the author makes as though she is speaking out loud; these touches make the book feel very personable. My favourite might be how she explains a topological defect in the same way as deciding which bread plate is yours at a fancy dinner. The epilogue is another highlight, where various cosmologists contemplate the end of the Universe. It's intriguing to read that while this subject is 'sad', it really is all about the journey.



▲ **When the door finally shuts on our Universe, how will it end?**

I can't remember coming across another book which solely focuses on the eventual destruction of all of reality. Mack is a great science communicator and I suspected I was going to like this book as soon as I saw her name; I am pleased to say it does not disappoint. ★★★★★

***Laura Nuttall** is a senior lecturer in gravitational waves at the University of Portsmouth*

VALERYBROZHINSKY/ISTOCK/GETTY IMAGES

Interview with the author
Katie Mack

How do scientists think the Universe will end?

The theory most currently accepted is 'heat death'. The Universe is expanding, galaxies are getting farther apart, so over time there will be fewer interactions between galaxies and less gas brought in to form new stars. Stars will fade and die, particles will decay and black holes will evaporate. It'll be a Universe that's empty, dark and cold, where the only thing left is waste heat from the destruction of everything. In the book I explore other possibilities, but none is a 'happily ever after' scenario.

How might humans experience the end?

In the 'big rip' scenario you'd watch stars at the Galaxy's edge drift away, the Milky Way fade out in the night sky and Earth drift from the Sun before being torn apart. You could get into a space capsule and wait it out but then, close to the end, your space capsule itself would get ripped apart and, finally, your own atoms.

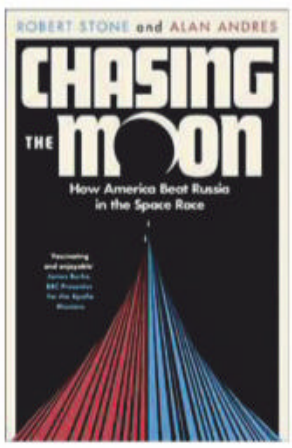
What astounds you most about the Universe?

Even though we're insignificant beings, we can understand what the Universe is made of and its evolution, and we can extrapolate into the future. When you look out into the cosmos, you're looking into the past because light takes time to travel, so you can observe a galaxy a billion lightyears away and see the light that came to us a billion years ago. We can see a Universe that's still on fire from the heat of creation. I'm proud that humans figured that out, and I'm lucky to be in a cosmos where we can learn and see all that.

***Dr Katie Mack** is a cosmologist and a science communicator at North Carolina State University*

Chasing the Moon: How America Beat Russia in the Space Race

Robert Stone and Alan Andres
William Collins
£9.99 ● PB



In 1899, a 17-year-old Robert Goddard climbs a cherry tree. While up there, he decides to devote his life to making rockets to reach other planets. Such a casually startling vignette is typical of *Chasing the Moon*, the companion volume to the US Apollo documentary. It recounts the stories that lack the footage to make it into the final cut, focusing on key ideas that led to the lunar landings, those who conceived them and the fascinating ways they interact.

We start with a portrait of teenage 'Archie' C Clarke buying his first rocketry book in WH Smith, then switch to that book's writer, science fiction editor – and Goddard confidant – David Lasser, who gets fired for his socialism. We meet contrasting German rocket scientists: pacifist Willy Ley and war-tainted Wernher von Braun, only one of whom gets hired by the US government. We move onto NASA personnel, with Frank Borman's Apollo 1 accident enquiry testament saving Apollo.

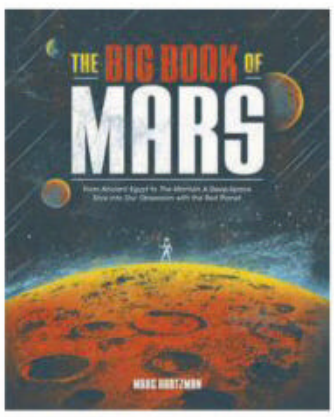
Space and social progress prove intertwined. Edward Dwight is JFK's choice as first black astronaut, until institutional racism pushes back; female mission controller Poppy Northcutt becomes a feminist icon. Clarke moves to Sri Lanka for its tolerant views on sexuality. As von Braun launches a telecom satellite, he gets Clarke a ground station – making him an early adopter of global connectivity.

This kaleidoscopic work is not standard space history – more focused on why than how – but is recommended. ★★★★☆

***Sean Blair** writes for the European Space Agency website*

The Big Book of Mars

Marc Hartzman
Quirk Books
£19.99 ● PB



The Red Planet has captured our imagination since ancient times, but when we thought that we had discovered canals etched across its surface in the late 19th century, speculation went into overdrive and we have obsessed over the possibility of Martian life and civilisations ever since.

The Big Book of Mars chronicles that fascination and introduces us to a parade of characters. There are noted scientists with their theories about how to search out and make contact with life on Mars and what that life might look like, through to complete crackpots who claimed to already be in regular psychic conversation with our near planetary neighbours. Scientific robotic missions to search for signs of life are discussed, as well as the many plans afoot to attempt to establish a human colony there.

Mars has had a huge influence on our popular culture, from the novel and infamous radio production of *The War of the Worlds* that caused panic across America in 1938, through to television, music, cartoons and sci-fi movies like *A Trip to Mars* (1918) and *The Martian* (2015). All are mentioned here, the good, the bad and the barmy.

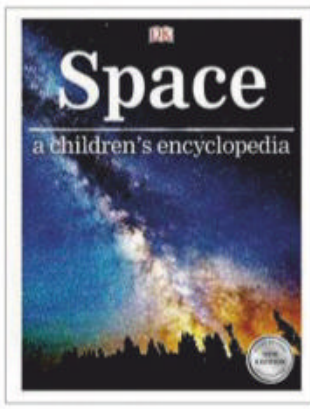
The writing style is informal and chatty, and the text is well illustrated. You won't find much hard science here, nothing about Mars formation, composition or orbit. Perhaps the title is a little misleading in that respect, suggesting a more comprehensive look at the Red Planet itself, but nonetheless it's an enjoyable celebration of our relationship with Mars. ★★★★☆

***Jenny Winder** is a freelance science writer, astronomer and broadcaster*

Space: a Children's Encyclopedia

GREAT FOR KIDS

DK reference book
DK Children
£19.99 ● HB



Comprehensive, slick and beautifully illustrated, this DK encyclopedia for children lives up to its publisher's reputation for accessible and trustworthy guides. The introduction promises a 'voyage through space and time' and indeed it more than delivers.

Delving into everything from the birth of the Universe and Earth's place in the Milky Way to the nitty-gritty of how different telescopes work and what it takes to become an astronaut, it employs stunning graphics, fact file boxes, profiles and timelines. All of these will have great appeal for children, as will its thoughtful selection of kid-friendly – indeed adult-friendly – facts. I was delighted to see an astronaut meal laid out in an annotated photo, for example, and to learn that the ISS's menu offers over 100 different meals and snacks.

While it contains such light-hearted facts, the book doesn't shy away from hard science or concepts that may be tougher for kids to grasp, like dark matter, dark energy and the use of the electromagnetic spectrum and redshift in astronomy.

The book has been updated since its first edition in 2010 and now mentions significant new events like New Horizons' flyby of a Kuiper Belt object and the first all-female space walk outside the ISS. It also nods to space tourism plans, although there could have been more depth on this. But this is a tiny criticism of an otherwise all-encompassing overview of space.

Space: a Children's Encyclopedia is a perfect ratio of the light and fluffy to the serious and informative. A beautiful and enjoyable experience for the reader. ★★★★½

***Shaoni Bhattacharya** is a science writer and journalist*

Ezzy Pearson rounds up the latest astronomical accessories

GEAR

1 Pleiades face mask

Price £11.90 • **Supplier** astroshop.eu
www.astroshop.eu

Announce your love of astronomy while protecting those around you with the help of this reusable face mask decorated with a picture of the Pleiades. Consists of a two-ply face mask with a wire nose clip.

2 Build your own cardboard telescope kit

Price £19.99 • **Supplier** Build Your Own
https://buildyourownkits.com

With all the lenses, mirrors and other parts needed to build your own cardboard telescope, this kit is a great way to teach budding astronomers how telescopes work. Importantly, it also leaves you with your own scope to begin exploring the night sky.

3 Fizz Creations space string lights

Price £10 • **Supplier** Argos
www.argos.co.uk

Decorate your room and discover the Solar System with this string of LED lights, which features the Sun, all eight major planets and Pluto. Requires two AA batteries.

4 Orion 2x54 ultra wide-angle binoculars

Price £144.99 • **Supplier** Orion
Tel: 0800 041 8146 • **uk.telescope.com**

ADVANCED By brightening fainter stars while still giving a wide-field view of the sky, these lightweight binoculars help to bridge the gap between naked-eye astronomy and more advanced binocular observing.

5 Folding camping table

Price £24.99 • **Supplier** Trespass
www.trespass.com

This table is the perfect place to lay out your accessories so you can find them during the night. It then rolls up and packs away neatly when it's time to go home. Measures 70cm high and weighs 3.1kg.

6 Bino bandit

Price £18 • **Supplier** Vortex
www.newprouk.co.uk

When it's fitted around the eyepieces of your binoculars, this guard will help to block out ambient light and wind, ensuring your eyes can make the most of every photon coming through the optics from deep in space.

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Shaoni Bhattacharya interviews Dr Lynn J Rothschild

Q&A WITH AN ASTROBIOLOGIST

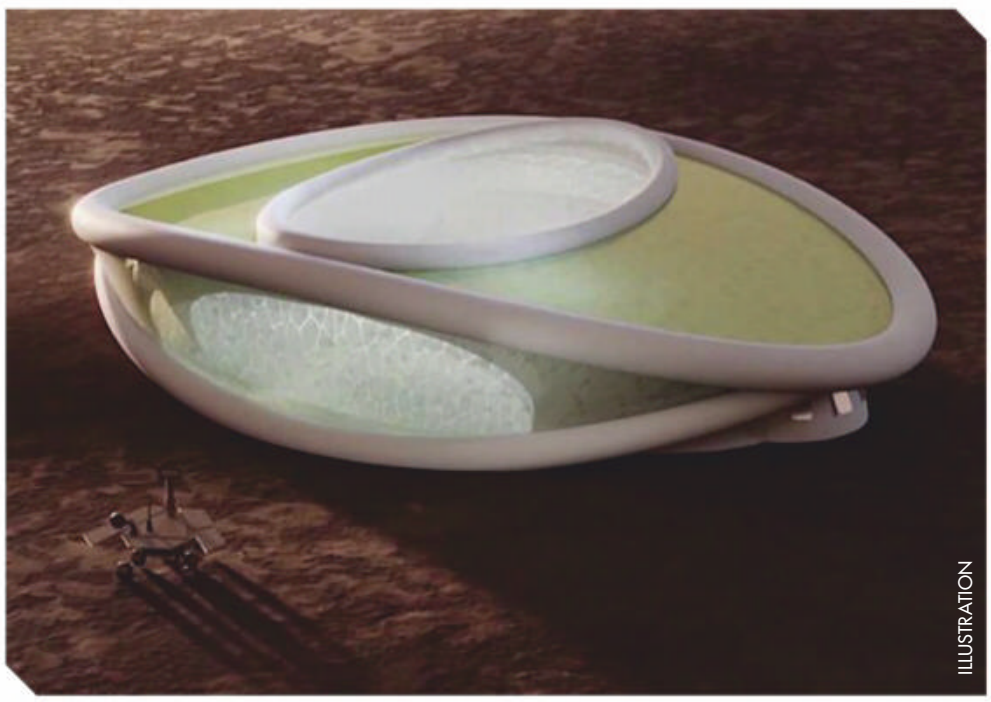
NASA is looking at ways to successfully build habitats on the Moon and Mars – including growing them out of mushrooms

What are the major challenges of setting up a base on the Moon or Mars?
The two major challenges are adjusting to different gravity regimes and radiation. The Moon is close by so it takes a short time to get there. When you land it's a sixth of Earth's gravity, and there's no atmosphere so the radiation's harsh. Mars is a longer trip; six months to get there, a year and a half to get planetary alignment, then six months back. The Martian atmosphere provides a bit of protection and the gravity is a third of Earth's. Then you need a home; you have to keep the atmospheric pressure up inside because you want to be able to breathe and not be in closed mobile spacesuits all the time.

What's your idea for building on the Moon or Mars?
In our research proposal to NASA I said a turtle brings its house with it but has to spend a lot of energy lugging around its shell – that's like bringing a pre-made habitat from Earth. There are NASA scientists working on designing habitats you can make with surface material, but we suggest another faster and low-equipment approach, which is using fungi to build a house.

When you eat a mushroom you are eating the fruiting body of a filamentous fungus; the real body is underground and consists of a network of fine hairs called mycelia. It's already been discovered that if you build a shape, put some fungal food in and inoculate with mycelia, they will grow to fill the structure. With this you can build a continuous structure: go around corners, make joints and make huge boards. Our idea is to use that approach to build off-Earth habitats.

How do you build a space habitat from fungi?
We would start with a double-bag, like a plastic bag one inside the other. In the middle part you have a very lightweight, collapsible scaffold that you've laced with dried fungal mycelia, and a few small containers with water. It would fold up and when you get to your destination you just add water and the structure inflates and the fungi grow to fill the scaffold – you've got your habitat. The double-bag keeps the pressure and vapour inside to prevent contaminating the planet and functions as a built-in barrier so you can ramp up the oxygen level inside.



ILLUSTRATION

▲ **Mushroom effect: to create an off-Earth habitat, water could be added to a basic structure to allow fungi to grow around its frame**

How would mushroom houses on Mars work for a mission?
For a major habitat on Mars, I would strongly urge NASA to have a precursor mission to set things up. When you go on holiday, you don't expect to arrive and then wait for a hotel to be built. I'd love to have it so this thing is able erect itself. Basically, you release water inside the bag and the fungus starts growing.

What makes fungi a better building material than other options?
You could turn regolith, surface material, into concrete, but that will take a lot of heavy-duty equipment. It might be useful to have our habitat in place and then build some regolith, heavy-duty material around it. Another idea was a 3D-printed ice house, which was an interesting idea, but there are issues including cracking and melting, and water is not in infinite supply. The obvious option is to just bring the whole thing with you, but these structures would be of substantial volume and incredibly high mass, so we would be spending an enormous amount of energy to get them to Mars.

How long would it take to grow a habitat from fungi?
Around a month. With anything biological the growth rate depends on environmental conditions, but by using synthetic biology we may be able to fine-tune this. One strain I chose to work on is full of lipids, or fat, which could provide more radiation protection – you could play with that using synthetic biology techniques. There's interest in engineering fungi with higher levels of pigments like melanin for protecting from UV radiation.

How far away is the reality of us having off-Earth mushroom homes?
Honestly, that's as much a political question as a scientific one. NASA has been instructed to have two humans on the Moon by 2024, in what's called the Artemis programme. Whether we will meet those deadlines is above my pay grade.

Dr Lynn J Rothschild is an astrobiologist and synthetic biologist at NASA's Ames Research Center in California's Silicon Valley

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THE SOUTHERN HEMISPHERE

With Glenn Dawes

Catch a display of Jupiter's moons, and glimpse our Galaxy's core through Baade's Window

When to use this chart

1 Aug at 24:00 AEST (14:00 UT)
15 Aug at 23:00 AEST (13:00 UT)
31 Aug at 22:00 AEST (12:00 UT)

The chart accurately matches the sky on the dates and times shown for Sydney, Australia. The sky is different at other times as the stars crossing it set four minutes earlier each night.

AUGUST HIGHLIGHTS

In August, watch the changing pattern of Jupiter's satellites. It's fascinating to watch the Galilean moons as they shuffle back and forth across the planet. They are particularly eye-catching when all four are on the same side, such as on the evenings of the 1st, 15th, 21st and 29th. A rarer event is on the 12th; between the start of a transit of Io at 00:30 and the reappearance of Ganymede from eclipse 87 minutes later, as only one moon (Europa) can be seen away from Jupiter's disc.

STARS AND CONSTELLATIONS

Look towards the hub of our Galaxy, around Sagittarius, Scorpius and Ophiuchus, and numerous dark nebulae are superimposed on the bright Milky Way. This prevents us from gazing into the centre, but there are a few clearings where the veil is lifted. One of these is Baade's Window, a bright region northwest of the Teapot's spout star Gamma Sagittarii; it's about 1° across and centred on globular cluster NGC 6522. An eyepiece will reveal stars to within 2,000 lightyears of the Galaxy's centre.

THE PLANETS

Jupiter and Saturn are high in the evening sky, being due north around 22:00 mid-month. At this time Mars is rising, to be followed by Uranus about two hours later. Both planets are best observed in the morning. Venus is already well up at the start of dawn, reaching its maximum distance from the Sun on 13th. It shows a half-lit disc during the month (similar to a first quarter Moon). Neptune appears in the early evening and is visible for the rest of the night.

DEEP-SKY OBJECTS

The constellation of Lyra, the Lyre, stands out in the night sky with its bright alpha star, Vega (low in the north) and a distinctive parallelogram of four stars just above. One of these, Beta Lyrae (RA 18h 50.1m, dec. +33° 22') is one of the brightest variable stars known, oscillating between mag. +3.2 and +4.4. Its full cycle takes 12.9 days and nearby Gamma Lyrae makes a convenient reference star with a magnitude of +3.2.

Lyra is renowned for its double-double star, Epsilon Lyrae. However, it has another lesser-known double-double, 3° NE of Gamma Lyrae. Struve 2470 (RA 19h 08.8m, dec. +34° 46) has mag. +6.7 and mag. +8.5 components separated by 13". In the same field of view (0.2° S) is another, Struve 2474, with mag. +6.7 and +8.2 stars 16" apart. These compelling pairs look like mirror images with both fainter companions due west of their primaries – very striking.

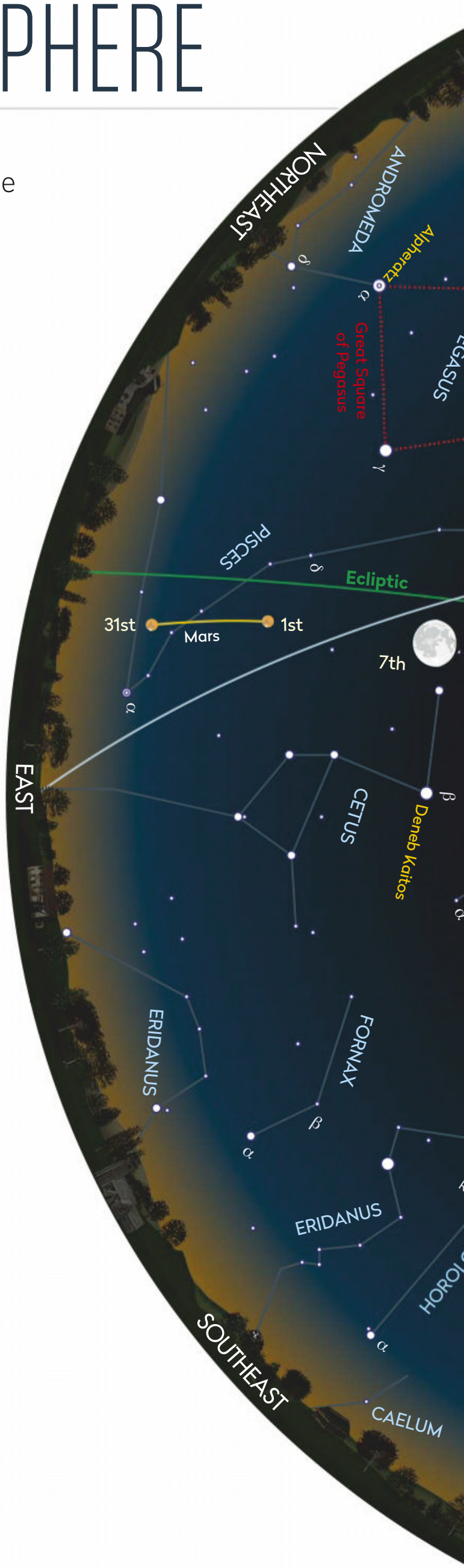
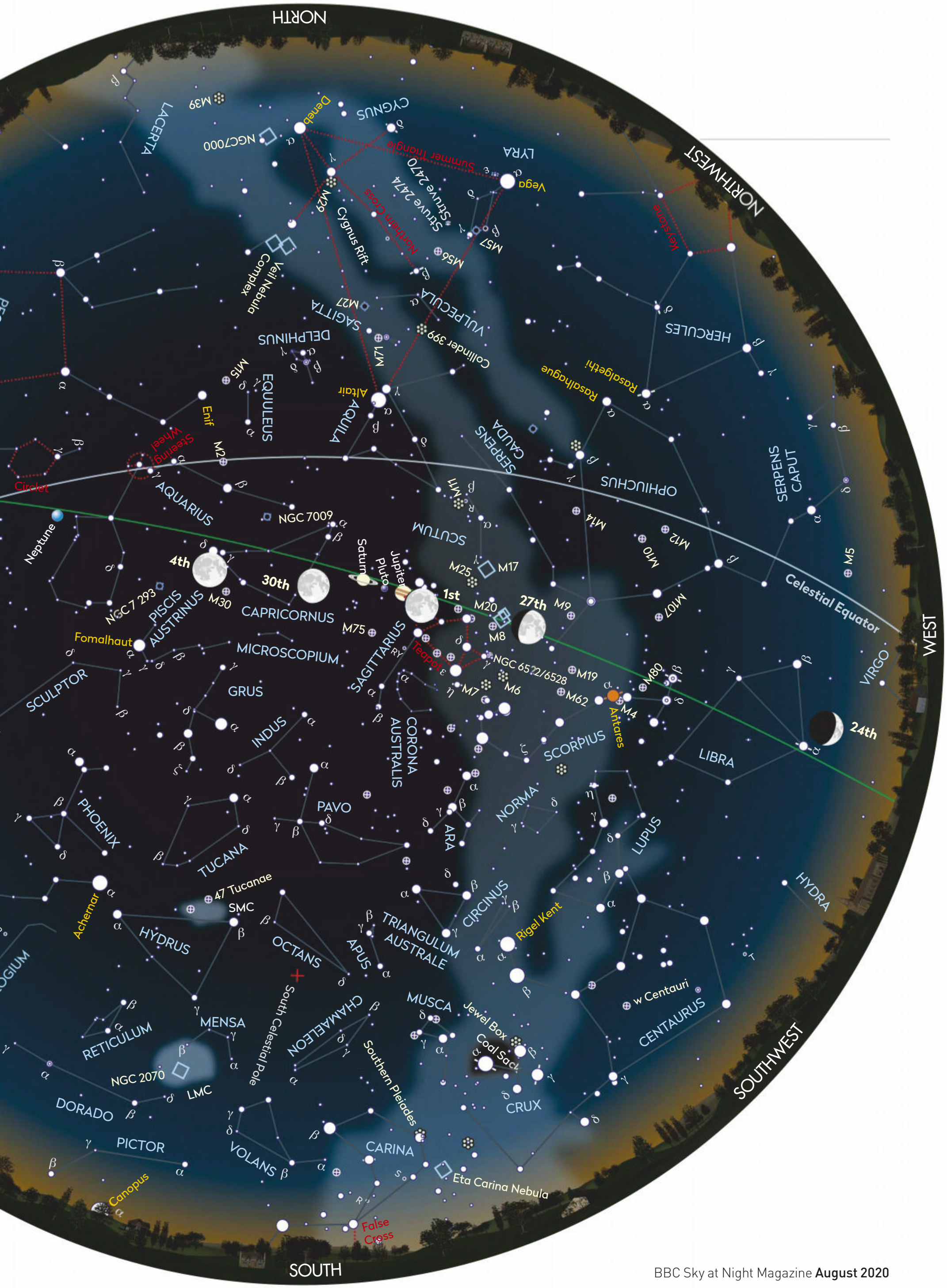


Chart key

- GALAXY
- OPEN CLUSTER
- GLOBULAR CLUSTER
- PLANETARY NEBULA
- DIFFUSE NEBULOSITY
- DOUBLE STAR
- VARIABLE STAR
- COMET TRACK
- ASTEROID TRACK
- METEOR RADIANT
- QUASAR
- PLANET

STAR BRIGHTNESS:
- MAG. 0 & BRIGHTER
- MAG. +1
- MAG. +2
- MAG. +3
- MAG. +4 & FAINTER

CHART: PETE LAWRENCE


NORTH
NORTHWEST
WEST
SOUTHWEST
SOUTH
LACERTA
M39
Deneb
CYGNUS
NGC7000
Summer Triangle
LYRA
Vega
Keystone
M29
Cygnus Rift
Struve 2474
Struve 2470
Northern Cross
M57
M56
Veil Nebula Complex
M27
SAGITTA
VULPECULA
Collinder 399
HERCULES
DELPHINUS
M71
Altair
Rasalhague
Rasalgethi
M5
EQUULEUS
AQUILA
SERPENS CAUDA
Enif
Steering Wheel
M2
Circlet
AQUARIUS
M11
OPHIUCHUS
SERPENS CAPUT
NGC 7009
Neptune
SCUTUM
M14
M12
M10
M5
Saturn
Jupiter
Pluto
4th
30th
1st
27th
M25
M17
M20
M9
M107
Celestial Equator
NGC 7 293
PISCIS AUSTRINUS
M30
CAPRICORNUS
M75
M8
Fomalhaut
MICROSCOPIUM
Teapot
NGC 6522/6528
M19
M80
M62
M4
Antares
M7
M6
SAGITTARIUS
CORONA AUSTRALIS
24th
SCULPTOR
GRUS
INDUS
SCORPIUS
LIBRA
VIRGO
PHOENIX
PAVO
NORMA
ARA
LUPUS
TUCANA
47 Tucanae
SMC
Achernar
HYDRUS
TRIANGULUM AUSTRALE
CIRCINUS
Rigel Kent
HYDRA
OCTANS
APUS
w Centauri
MUSCA
Jewel Box
Coal Sack
CENTAURUS
MENSA
RETICULUM
CHAMAELEON
South Celestial Pole
NGC 2070
LMC
Southern Pleiades
CRUX
DORADO
PICTOR
VOLANS
CARINA
Eta Carina Nebula
Canopus
False Cross